SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MAY 1899.

GENERAL PHYSICS.

639. *Homogeneous Deformation.* **L. Januszkiewicz** and **W. Voigt.** (Wied. Annalen, 67. 2. pp. 452–458, 1899.)—The authors tested the strength of rock salt in air and under a pressure of 52 atmospheres, exposing it to the same tensile strain, in order to determine a possible effect of cross pressure upon tensile strength. But they found no difference in the two cases. E. E. F.

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640. *Deformations of Metals.* **M. Brillouin.** (Annal. Chim. Phys. 14. pp. 311–331, and 15. pp. 447–469, 1898.)—In the first place the author imagines a substance composed of perfectly elastic particles embedded in a network of viscous matter. He studies the way the substance would behave when subjected to forced and to free oscillations. To some extent the results agree with practice. In one case the theory differs from practice; for example, the author finds that the logarithmic decrement given by the ideal substance when subjected to torsional vibration should be largely dependent on the period, a result differing from some of Tomlinson's observations.

Partly on this account the author is led to consider a structure in which the particles possess viscosity as well as elasticity. He does not find, like Tomlinson did in certain cases, that the decrement is independent of the period. He finds, however, that the decrement is a variable which passes through a minimum value, and at this point the change in the decrement is small.

Finally a specific structure, resembling brickwork, is considered, and its behaviour under traction and compression very carefully examined, even the surface tension of the viscous matter being taken into account, when free surfaces are developed in the pores under prolonged traction. A. Gs.

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641. *Deformation of Marble.* **P. Gamba.** (N. Cimento, 8. 4. pp. 273–284, 1898.)—A slab of marble supported at its extremities is subjected to both upward and downward forces at its centre. The deformations are measured optically, each end of the slab being provided with an upright mirror. A ray of light is reflected twice by one mirror, and once by the other; thus an angular movement is magnified six times. Curves are given indicating the deformations produced when the slab passes through unilateral and bilateral cycles. A. Gs.

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642. *Measurement of Twisting Strains.* **E. G. Coker.** (Phil. Mag. 46. pp. 520–528, 1898.)—This paper, read at the Bristol Meeting of the British Association, 1898, describes two arrangements of apparatus for measuring small strains in bars subjected to twist and for the determination of the Modulus of Rigidity. One form of the apparatus consists of a graduated circle mounted on a chuck-plate, having three centring-screws adjustable by hand. A ring secured to the test bar at a known distance carries an arm in which slides a tube, so that a contact-ball at its outer end can be brought into position touching the end of a screw-micrometer gauge carried on the vernier-plate of the graduated circle. When the contact pieces are touching, an electric circuit is completed through the test bar, and a galvanometer-needle is deflected. A twisting-moment being applied to the test-bar the contact pieces are separated, and the micrometer-screw must be advanced until the circuit is completed. The number of divisions through which the screw has been turned gives a measure of the angular displacement. The calibration of the instrument is described.

A clamp-bar for the purpose of setting the graduated circle accurately, with its plane perpendicular thereto and its centre corresponding with the longitudinal axis of the bar, is described. In the second form of the apparatus a reading microscope is used to observe the relative angular displacement of a radial line upon the vernier-plate. The graduated circle of this instrument is carried by a self-centring chuck of somewhat novel form, which is fully described in the paper. Illustrations of the instrument and details of calibration tests are given. A. S.

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643. *Elasticity of Muscle and of Rubber.* **A. Chauveau.** (Comptes Rendus, 127. pp. 1180–1189, 1898.)—The muscle behaves under load like a metallic rod, but its elasticity increases after each partial stretching. A muscle (forearm), sustaining 250, 500, 750, 1,000, 1,250 g. and then further weighted with 250, 500, 750 . . . g. is in each of these cases stretched by the same amount. But when five loads of 250 g. are applied successively, the partial extensions of the muscle under

each additional 250 g. decrease more and more, so that the total extension is less (about half) than that which results when the whole 1250 g. are applied at one time. The extension depends upon the ratio of additional load to weight sustained. The case is different with vulcanised rubber, whose extensions increase more rapidly than the loads. The experiments were made with rubber tubings, 0·20, 0·40, and 0·60 m. in length, with solid rubber threads, and with rubber belts, the partial loads being increased from 250 to 750 g. H. B.

644. *Capillary Constants.* **A. Gradenwitz.** (Wied. Annalen, 67. 2. pp. 467–473, 1899.)—The author tests the validity of Quincke's method of determining capillary constants from solidified drops. It is impossible to obtain accurate values of the curvature owing to the roughness of the surface. The best method consists in projecting the drops enlarged upon a transparent screen of section paper, and measuring the height and width. Even so, errors are introduced by expansion and contraction on solidifying, or by the absorption of gases. Tin, silver, bismuth, water, and mercury were the bodies examined. E. E. F.

645. *Surface Tensions.* **A. Pockels.** (Wied. Annalen, 67. 3. pp. 668–681, 1899.)—The authoress determines the tension of the surface separating two liquids by means of the cohesion balance. One method employed consists in the direct measurement of the surface tension by dipping an adhesion ring into the lower liquid and then lifting it up. The other method is indirect. The second liquid is allowed to expand on a contaminated water surface. This reduces the surface tension of the water until the expansion ceases. The remaining surface tension of the water is then measured with the cohesion balance. The surface tension between the two liquids is then obtained by deducting the surface tension of the upper liquid from the surface tension of equilibrium. Measurements made by the first method show a rapid reduction of the intermediate surface tension with time. Thus the surface tension water-benzol was 3·43 mg./mm. when fresh, and 3·22 after ten minutes. This recalls the behaviour of pure water on exposure to air, except that the change is more rapid. Like contaminated water, the surface tension increases on expansion and diminishes on contraction. The authoress also shows how the purity of oils may be tested. It suffices to pour drops of the two oils on to the same water surface. That which shows the colour corresponding to the greater thickness is the purer of the two. E. E. F.

646. *Improved Barometer.* **K. R. Koch.** (Wied. Annalen, 67. 2. pp. 485–488, 1899.)—The author has introduced several improvements in his standard barometer constructed in 1895. The mercury is introduced into the vacuum by distillation. The volume of the vacuum is so large that air creeping up into it does not produce a perceptible difference of pressure. Moisture is kept down by a large quantity of phosphoric pentoxide. The vacuum can be tested at any time by a vacuum tube, which is furnished with outside electrodes to avoid occluded gases. If the vacuum is faulty, it can be restored by means of a permanently attached Sprengel pump. E. E. F.

647. *Geissler Pumps.* **G. Guglielmo.** (Roma, R. Accad. Lincei Atti, 7. pp. 240–249, 1898.)—The author describes two forms of pump, which he considers to have advantages over the ordinary design in being more portable and less liable to injury; moreover, the intrusion of air from outside is practically impossible, even with stopcocks not very accurately fitted, and the degree of rarefaction obtained may be easily and exactly determined. Two figures are given in which the essential parts are drawn to scale. G. B. M.

648. *Hydrodynamics.* **E. W. Brown.** (Science, 8. pp. 641–651, 1898.)—An interesting semi-popular *résumé* of recent progress towards the solution of problems in hydrodynamics, and of the outstanding difficulties. A. D.

649. *Interpretation of a Limited Number of Results.* **E. Vallier.** (Comptes Rendus, 128. pp. 654–656, 1899.)—When a large number of measurements of the same quantity are available it is correct to take their arithmetical mean. But when the number of readings is small, a single reading, differing widely from the others, is usually omitted. This is obviously incorrect, since, if the reading is a high one, a lower mean result is obtained than if it had been a less high one. The author therefore gives the following rule: If only a limited number of readings are available, and a widely divergent value is amongst them, for which there is no intrinsic improbability, take the arithmetical mean of all the values, and add to it the quantity, $-\frac{1}{2}\frac{s_3}{s_2}$, where s_2 is the sum of the squares, and s_3 the sum of the cubes of the differences from the arithmetical mean. E. E. F.

650. *Ancient Mirrors.* **Berthelot.** (Annal. Chim. Phys. 15. pp. 433–444, 1898.)—Classical specimens, of various provenance, are seen to have been made by blowing a thin-walled ($\frac{1}{4}$ mm.) bulb of glass and pouring melted lead into a watch-glass-shaped portion thereof, and manipulating so as to spread the metal into a lining layer about $\frac{1}{10}$ mm. thick. The glass had to be thin enough not to crack on contact with the melted lead. A. D.

651. *Physiological Action of Alternating Currents.* **J. L. Prevost** and **F. Battelli.** (Comptes Rendus, 128. pp. 668–670, 1899.)—The authors give the results of 170 experiments made upon dogs, cats, guineapigs, rabbits, and rats, with currents of 45 periods per second, and with 5 to 4,800 volts. High-tension currents applied for a fraction of a second between the head and the feet produce grave troubles of the nervous system, including convulsions and temporary or permanent suspension of the respiration. The auricles of the heart are stopped in diastole, while the ventricular contractions proceed as before. Impending death can often be averted by artificial respiration.

Lower E.M.F.s, say 60 volts, produce tetanic convulsions, but only when applied to the head. When the contact exceeds a second, fibrillary tremblings of the ventricles set in, which in the case of the dog are fatal. In the other animals, paralysis of the heart may be obviated by a short application of a current of high tension, and by artificial respiration. There is no appreciable rise of temperature, unless the application of the current is prolonged. *Post-mortem* examinations show no intra-cerebral hemorrhage nor any other constant characteristics of death by electricity. E. E. F.

652. *Theory of Bicycle-Steering.* **G. T. McCaw.** (Engineer, 86, p. 557, 1898.)—A mathematical investigation of the effect of rake, and distance of the centre of front wheel from the steering axis, on the steering of a bicycle. The practical results deduced from the formula are as follows: In the first place, a choice of rake is allowed, but the angle of rake having been chosen, the position of the steering axis is absolutely fixed for a given speed, the distance from point of front wheel contact with base line to the point where the steering axis cuts the ground being inversely proportional to the sine of the angle of rake, inversely proportional to the fraction of the resultant weight on the front wheel, and directly proportional to the square of the speed. In an example worked out, for a speed of $10\frac{1}{2}$ miles per hour, this distance varies from 5·33″ to 2·40″ for rake angles 15° to 35°; while the distance betweeen front wheel centre and steering axis varies from 1·53″ to 6·06″. A. S.

653. *Absolute Velocity and the Ether.* **O. Lodge.** (Phil. Mag. 46. pp. 414–426, 1898.)—The author is of opinion that energy has all the marks of objectivity, and states a series of propositions, of which the last three are: "(6) Stresses exist solely in the Ether; (7) the Ether as a whole is at rest, and Velocities referred to it are Absolute velocities; (8) the two fundamental Forms of Energy are distinct and are possessed by different bodies, viz., Potential by ether, Kinetic by matter; hence whenever there is transference there is transformation, and whenever there is transformation there is transference." In a subsequent parenthesis it is remarked that "there is nothing here to prevent etherial energy from being ultimately hydro-dynamically kinetic, but considered from the practical material point of view etherial energy is what it has been agreed to call 'potential'; *i.e.*, it displays itself as a force to which matter can yield, rather than as a motion which something in space can resist." G. B. M.

654. *Inertia as a Manifestation of the Ether.* **C. Barus.** (Science, 8. pp. 681–685, 1898.)—The author describes experiments, in which a fine tube contains in the centre a thread of coagulated gelatine solution, and at either end a thread of mercury. Pressure being applied to the mercury at one end, globules of mercury pass in succession through the solution towards the other end. Instead of the gelatine solution now suppose ether. Barus claims the right to make his ether solid or liquid, continuous and rigid, or discontinuous, triturated, virtually rigid, as the conditions warrant. In fact, it may be defined as a solution of the differential equations of dynamics. If there be a body placed in the continuous ether, and an impulse be applied to it setting it in motion, there will be discontinuous or triturated ether behind the body, and sheared continuous ether in front of it. Then again he supposes the triturated region, however produced, to exist without any material particles. The triturated region is a seat of energy, and Barus says that it cannot be at rest, but must be continually breaking down the continuous ether in front of it or in all directions round it. The resistance to breaking down varies *cæteris paribus* as the velocity, and as the front presented to the continuous ether, which may then represent mass. This behaviour of the region he finds to be an approach to Newton's first and second laws of motion. S. H. B.

LIGHT.

655. *Optical Measurement of Diameters.* **M. Hamy.** (Comptes Rendus, 128, pp. 583–586, 1899.)—The author applies Fizeau's method (in which the objective of a telescope is covered with a screen containing two slits, whose distance apart is adjusted until the fringes in the focal plane disappear) to the measurement of the diameters of Jupiter's satellites and the planet Vesta. He constructed a series of screens with slits various distances apart, and found which of them made the fringes disappear. The results obtained accord very fairly with the best micrometric measurements. The diameter of Vesta, 0·54″, is precisely equal to Barnard's value. E. E. F.

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656. *Quartz Plate Normal to the Axis.* **R. Dongier.** (Journ. de Physique, 7. pp. 643–648, 1898.)—This paper describes and gives the theory of a method of control in making the parallel faces of a quartz plate normal to the axis.

The method was proposed by Beaulard, who used a banded spectrum instead of the Airy spirals used in practice. The apparatus, besides that necessary for producing the banded spectrum, consists of a graduated disc to carry the quartz plate, a polariser and an analyser. Before entering the spectroscope the parallel beam of white light traverses the quartz plate (placed between the polariser and analyser crossed) normally to its faces. The banded spectrum has then minimum intensity. If the plate is now inclined to the beam by rotating the disc, the bands are displaced towards the red end; and if the plate is well cut, the same number of bands will traverse the cross wires of the spectroscope for the same inclination on both sides of the normal. If the polariser and analyser are parallel, the bands lose their sharpness when the inclination increases in any plane which is not at 45° to the plane of polarisation. J. B. H.

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657. *Kinetic Theory of Crystalline Polarisation.* **J. Beckenkamp.** (Wied. Annalen, 67. 2. pp. 474–480, 1899.)—The pyroelectric phenomena of baryta and aragonite may be mechanically explained by supposing that in consequence of the heat motions of the atoms three ether currents, normal to each other, circulate round the molecule, and that at all places where there is a change in the path of the currents the ether pressure is above or below the normal. The author applies the same theory to the study of the rotation of the plane of polarisation in tridymite, and shows that in regular crystals the rotation is independent of the orientation of the crystals, but proportional to the length of the ray. E. E. F.

658. *Faraday Effect in Salt Solutions.* **S. Oppenheimer.** (Zeitschr. Phys. Chem. 27. pp. 447–456, 1898.)—A number of saline solutions were subjected to the action of a magnetising coil, and the rotation of the plane of polarisation of a beam traversing them was compared with the rotation produced by pure water. The following are the results:—

	Specific Rotation. (Water = 1.)	Molecular Rotation. (Water = 1.)
NaCl	1·66	5·38
KCl	1·32	5·50
NaBr	1·66	9·32
KBr	1·41	9·32
$CdCl_2$	1·14	11·24
CH_3 COOH	0·761	2·54

It will be seen that the values of the molecular rotation are the same in the two alkaline bromides, and very nearly so in the corresponding chlorides. In every case the specific rotation was found to be independent of the concentration. This is particularly surprising in the case of acetic acid, since Perkin and Schönrock found that hydrochloric acid showed a definite change of rotatory power with concentration. E. E. F.

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659. *Theory of the Zeeman Phenomenon.* **D. A. Goldhammer.** (Wied. Annalen, 67. 3. pp. 696–701, 1899.)—It is possible to explain the Zeeman effect on the basis of the older magneto-optic theories, without calling in the aid of conceptions of ionic motions. This is how the author proceeds to do so: If V_0 is the velocity of light in free ether, D the dielectric constant, κ the specific resistance of a body for the period T, and V the complex velocity of light in it, the electromagnetic theory of light gives—

$$\frac{V_0^2}{V^2} = D + i\frac{2T}{\kappa} \qquad (i = \sqrt{-1})$$

On introducing the real refractive index N and the coefficient of absorption K, we obtain—

$$D = N^2 - K^2,\ 2NK = \frac{2T}{\kappa}$$

and hence—

$$2N^2 = \sqrt{D^2 + \frac{4T^2}{\kappa^2}} + D,\ 2K^2 = \sqrt{D^2 + \frac{4T^2}{\kappa^2}} - D$$

Any change in D or κ, by whatever cause produced, must therefore bring about a change in N and K. It manifests itself in a change of the number and position of the absorption lines of the body, and, by Kirchhoff's law, of the emission spectrum also. The author studies the effect of a change of gaseous resistance produced by magnetisation, and shows that the Zeeman effect only differs from the Faraday effect by the presence of selective absorption and emission in the former. E. E. F.

660. *Grating-Spectroscope.* **H. Olsen.** (Zeitschr. Instrumentenk. 18. pp. 280–283, 1898.)—Describes an improved form of a type of instrument supplied by C. A. Steinheil Söhne, of Munich. G. B. M.

661. *Anomalous Dispersion of Cyanin.* **R. W. Wood.** (Phil. Mag. 46. pp. 380–386, 1898.)—By squeezing fused cyanin between two glass plates upon one of which a strip of paper is pasted, prisms of 10′ to 15′ angle with excellent optical surface may be produced. A table and diagram are given showing the values of the refractive index obtained with one of these prisms for the ranges 765–648 $\mu\mu$. and 508–395 $\mu\mu$. : the results agree well with those of Pflüger. The author has not yet succeeded in making prisms by his method thin enough to transmit yellow light, so the range 510 $\mu\mu$.–650 $\mu\mu$. is omitted. G. B. M.

662. *Condensation Nuclei.* **C. T. R. Wilson.** (Roy. Soc. Proc. 64. pp. 127–129, 1898.)—Ultra-violet rays act in moist air or oxygen like Röntgen and uranium rays in producing condensation nuclei, under the same degree of supersaturation; but in this case the nuclei grow. In hydrochloric acid ultra-violet rays produce few nuclei. Sunlight produces nuclei in moist air. Amalgamated zinc produces dense fogs under expansions which in the absence of the metal only result in the formation of a very few drops: clean zinc or lead a similar but much slighter effect: copper or tin inappreciable. Ultra-violet light acting on a negatively electrified zinc plate produces nuclei identical with those produced by Röntgen rays, not dust particles from the plate. Discharge from a pointed platinum wire in moist air or hydrogen produces identical nuclei if a glow be observable at the point of the wire. In all these cases the ratio of the final to the initial volume of the air required to produce such supersaturation (about fourfold) as will induce the deposition of moisture on the nuclei is 1·25. If the moist air examined under Röntgen or uranium rays be that in an electric field, the nuclei are much less numerous than in the absence of a field, and if the nuclei-forming rays are turned off before the expansion, the nuclei are found to be rapidly removed by the field; which shows the nuclei to be charged particles or ions. The nuclei produced by ultra-violet

rays or by the presence of metals are entirely unaffected by an electric field, and are therefore not ions: those produced by ultra-violet rays falling on a negatively charged plate are themselves charged. (See also 1898, Abstract No. 1033.) A. D.

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663. *Evaporation and Condensation under Röntgen Rays.* **P. Pettinelli.** (N. Cimento, 8. 4. pp. 299–303, 1898.)—Psychometric experiments indicate that Röntgen rays slightly accelerate evaporation and condensation in air at ordinary pressures and temperatures: an effect which the author attributes to a possible increase in the convective power of the air. A. D.

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664. *Another New Radio-active Element.* **P. Curie, Mme. P. Curie** and **G. Bémont.** (Comptes Rendus, 127. pp. 1215–1217, 1898.)—In addition to the new element polonium (see 1898, Abstract No. 1224, and 1899, Abstract No. 35) an entirely different element has been found in small traces in pitch-blende residues, in company with barium and analytically behaving as such, but extremely radio-active. By fractional precipitation of the chloride of barium from solution by means of alcohol, chlorides have been obtained containing chlorides of the new element ("radium") which have 900 times the radiant activity of metallic uranium. **M. Demarçay** (*ibidem*, p. 1218) has examined the spectrum and finds a notable line at $\lambda = 3814{\cdot}8$ (Rowland scale) not otherwise identifiable. The trace must be small, for the atomic weight of the barium is only very slightly altered, though it is always altered in one direction, that of increase as compared with inactive barium. The chloride of "radium" makes a photographic negative in half a minute where uranium or thorium or their compounds would take hours; and, through aluminium, it can render a film of platinocyanide of barium permanently luminous sufficiently to make it visible in the dark without any apparent supply of energy. Uranium and thorium do not produce this latter effect, probably because their action is too feeble. A. D.

HEAT.

665. *Specific Heat.* **L. Pfaundler.** (Wied. Annalen, 67. 2. pp. 439–443, 1899.)—Dealing with the source of error in Andrews' method for determining specific heats, pointed out by Gumlich and Wiebe, the author shows how the error may be eliminated by a suitable construction of Andrews' apparatus and a rational arrangement of the experiment. E. E. F.

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666. *Ratio of Specific Heats of Gases.* **L. Boltzmann.** (Comptes Rendus, 127. pp. 1009–1014, 1898.)—The author infers from the kinetic theory of gases that (1) the molecule of a perfect gas for which $k=1\frac{2}{3}$ behaves, so far as intermolecular collisions are concerned, like a rigid sphere; this probably holds good only for monatomic gases; (2) if $k=1{\cdot}4$, the molecule behaves, over a considerable range of temperature, like two spheres rigidly connected; this probably holds good only for diatomic gases; (3) at high temperatures k diminishes and becomes variable even for perfect gases; this is true at ordinary temperatures for triatomic and polyatomic gases; (4) for an imperfect gas which obeys the law of Van der Waals, k is always less than for a perfect gas with a molecule of the same constitution and internal qualities. But the law of Van der Waals is only a first approximation, and our knowledge of imperfect gases not enough to enable us to draw a general conclusion. The author suggests the desirability of new determinations of k for argon, mercury vapour, chlorine, air, hydrogen, &c., over as wide ranges of temperature and pressure as possible. G. B. M.

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667. *Boiling-point Curves.* **E. F. Thayer.** (Journ. Phys. Chem. 3. pp. 36–40, 1899).—Complete boiling-point curves are determined for mixtures of several liquids. The curve for mixtures of alcohol and chloroform has a minimum corresponding (at 732·5 mm.) to a mixture containing about 7 per cent. of alcohol and boiling at 58·5°.

For alcohol and acetone the boiling-points of all mixtures lie between those of the constituents. For acetone and chloroform the curve has a maximum corresponding (at 737·1 mm.) to a mixture containing about 19 per cent. of acetone and boiling at 63·4°. A mixture of benzene and alcohol containing 33·5 per cent. of alcohol distils unchanged at 66·7° under a pressure of 737 mm. (See also Lehfeldt, Abstract No. 61, 1898.) T. E.

668. *Boiling-point of Hydrogen under Reduced Pressure.* **J. Dewar.** (Roy. Soc. Proc. 64. pp. 227–231, 1899.)—Having previously found (Chem. Soc. J., June, 1898) that the b.p. of liquid H was $-238{\cdot}4^\circ$ C. (35° abs.), corresponding to a resistance of 0·129 ohm, it was calculated that if, by diminished pressure, the b.p. of hydrogen could be reduced 5° or 6° C., the resistance of the platinum wire thermometer would become *nil.* For a pressure of 25 mm., the data, b.p. 35° abs., critical temperature 52°, critical pressure 19·4 at., give a b.p. of $25{\cdot}4^\circ$ abs., while the molecular latent heat gives $26{\cdot}1^\circ$ abs., or a mean reduction of about 10°. In actual experiment great difficulties arose from (1) the conduction of heat by the wires of the thermometer, (2) the small latent heat of H, (3) the inefficiency of heat isolation and the strain on the thermometer caused by solid air freezing on it and distorting the coil of wire, (4) the liquid H evaporating before the required pressure was reached. The liquid evaporated quietly and steadily under 25 mm., without any change or loss of mobility. The original resistance of 0·131 ohm fell under diminished pressure to 0·114, remaining constant for some time, the lowest reading being 0·112. This value corresponds to $-239{\cdot}1^\circ$ C., or a reduction of only 1°, instead of 10°, as by theory. With a view to explain the discrepancy, the experiments are being repeated with a new thermometer of much higher initial resistance, larger quantities of liquid H, and better heat isolation. S. R.

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669. *Melting-point of Cast Iron.* **R. Moldenke.** (Indus. and Iron, 25. pp. 364–365, 1898).—The author devised a special form of the Le Chatelier pyrometer, for the purpose of making experiments on the melting-point of cast iron. The platinum wires for the thermo-couple are protected by a clay tip. Both wires are covered with asbestos to insulate them from each other, as well as to serve as a protection in case the clay tip breaks while in the molten iron. The sensitiveness of the couple, even though protected by a refractory material, is such that, plunging it cold into the melted iron, the correct reading is obtained in 1¾ minutes; while, when properly heated up to redness beforehand, this time is reduced to a few seconds. Forty-eight brands of pig-iron were experimented on; their chemical compositions and melting-points are given in tabular form. A number of cast irons and steels were also experimented on. With few exceptions the temperature at the melting-point increases as the combined carbon decreases, this being the case independent of the amount of graphitic carbon present. A. S.

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670. *Flame Temperatures.* **F. Berkenbusch.** (Wied. Annalen, 67. 3. pp. 649–667, 1899).—The author tests two new

methods indicated by Nernst for the measurement of flame temperatures. These methods are designed to eliminate the errors due to the difference of temperature produced by conduction and radiation between the flame and the thermo-element immersed in it. The first of these methods is founded upon an estimation of the rate of heating and cooling of the thermocouple. The temperature of the couple at which the transfer of heat from the flame to the couple would be zero is found by graphic extrapolation, and that temperature is the flame temperature sought. This method breaks down, however, owing to the impossibility of accurately estimating the loss of heat by convection. In Nernst's second method, the thermo-element is electrically heated to the temperature of the flame. The heat received from the flame is zero when the heat radiated or conducted away from the element is equal to the total heat due to the current. Hence it is only necessary to determine the loss at various temperatures under circumstances similar to an immersion in the flame. This is very nearly realised by heating in a vacuum. The heating is done by means of an alternating current. The results for a number of points in the interior of a Bunsen flame are in close accord with those given by Waggener, the mean result being 1830°. This agreement is supported by a thermo-chemical calculation of the temperature of the flame, which gives 1820° as its mean temperature, after allowing for the difference between the maximum temperature of the flame and the average temperature of the gases leaving it. E. E. F.

671. *Thermal Radiation.* **K. Ångström.** (Wied. Annalen, 67. 3. pp. 633–648, 1899.)—The author describes a new instrument for the measurement of thermal radiation, which he calls the electric compensation pyrheliometer. It resembles in some ways the author's apparatus described in 1893, and that described by Kurlbaum in 1894. The instrument is based upon the following principle: Of two thin metallic strips, similar in every respect, one is exposed to the radiation to be measured, while the other is heated to a corresponding amount by means of an electric current. When equilibrium is attained, the energy radiated by each of the strips is equal to the energy supplied by the current and the source respectively. If q is the radiation per sq. cm. per second in gramme-calories, b the width, a the absorptivity of the strip, r its resistance per unit length, and i the strength of the compensating current, then

$$b\,a\,q = \frac{ri^2}{4{\cdot}18}$$

The arrangement adopted eliminates almost all sources of error. The author gives full particulars of construction and use, and quotes a series of measurements of solar radiation made on Teneriffe, and of the radiation of a Hefner lamp. E. E. F.

672. *Thermal Conductivity of Rocks.* **F. Morano.** (Roma, R. Accad. Lincei Atti, 7. 2. pp. 61–68, 83–89, 1898).—The samples experimented on were circular discs from rocks in the Roman Campagna, and the author first gives a mathematical discussion, involving Bessel functions, which does not admit of analysis. This is followed by accounts of the determination of the specific heats, densities, dimensions, and conductivities of the discs. Finally, tables are given to show the diurnal and annual variation of temperature at the surface and at different depths. G. B. M.

673. *Diathermancy of Ebonite.* **E. Bianchi.** (N. Cimento, 8. 9. pp. 285–295, 1898).—The diathermancy is 8·72 per cent. when the source of heat is a Leslie's cube at 100°, to 11·11 when it is melted lead at 320°, with intermediate values and with higher values at increasing temperatures, up to 45 per cent. for radiations coming from platinum wire at its maximum luminosity and passed through 4 mm. of alum (diathermancy 9·5). The thickness of ebonite employed was 0·5 mm. When the whole radiation from the incandescent platinum wire impinged on the ebonite, the diathermancy was only 26·2 per cent. Ebonite is thus somewhat diathermanous for sources at 100° (Becquerel *contrà*, Journ. de Phys. 6, series 3, p. 525, 1897); and it is more diathermanous to the more refrangible heat-rays. A. D.

674. *Saturated Vapours.* **E. H. Amagat.** (Comptes Rendus, 128. pp. 649–653, 1899.)—The author points out that his form of the function, $f(p, v, t)=0$, very nearly agrees with the observed values for saturated vapours even near the critical temperature. Between the points there is a divergence which is possibly accounted for by the great difficulty of experimental determinations in that region. E. E. F.

675. *Thermodynamics.* **K. Wesendonck.** (Wied. Annalen, 67. 2. pp. 444–451, 1899.)—When the working body receives its heat by radiation, it is only the temperatures of the surface and volume elements receiving heat from outside which should enter into discussion. E. E. F.

ELECTRICITY.

676. *Report on the State of the Mathematical Theory of Electricity and Magnetism.* **A. G. Webster.** (Science, 8. pp. 803–810, 1898.)—This is a historical sketch of the theory commencing in 1848, at which date Coulomb had already demonstrated the law of the inverse square, thus admitting the potential theory of Laplace, Poisson, and Green. The laws of current induction were subsequently established experimentally by Oersted and Faraday, and expressed analytically by Neumann. The next epoch is marked by Maxwell's work, and mention is made of other writers who, following in his steps, helped to complete or elucidate the theory. Maxwell's field equations are given, and finally the work of Hertz and Heaviside, and the theory as now existing is given in the form of a system of field equations to be compared with those of Maxwell. S. H. B.

677. *Dirichlet's Principle.* **W. Stekloff.** (Comptes Rendus, 128. pp. 588–591, 1899.)—The author shows how problems of electrostatic distribution can be solved without the aid of Dirichlet's principle and without the introduction of doubtful premises, by a combination of the methods of Neumann, Poincaré, and Liapounoff. E. E. F.

678. *Alternating Electric Arc.* **A. Blondel.** (Comptes Rendus, 127. pp. 1016–1021, 1898.)—Contains a series of figures showing the variation, with the time, of the potential difference between the points of the carbons and the corresponding current intensity. The nature of the curves obtained depends upon the kind of carbons used and the inductive or non-inductive character of the circuit. The "normal arc" is obtained by using pure homogeneous carbons, as the presence of a core or of mineral salts tends to mask the characteristic features of the phenomenon.
G. B. M.

679. *Electric Arc.* **F. Eichberg** and **L. Kallir.** (Écl. Électr. 17. pp. 560–566, 1898.)—The electric-arc when excited by alternating currents between electrodes of different metals shows a steady deflection on a tangent galvanometer placed in circuit with it, indicating the presence of a continuous current. This paper contains an experimental investigation of this phenomenon.

One electrode is of carbon and the other of iron. The quantities measured are: 1. The average current in the circuit, by means of a thermal ammeter. 2. The average difference of potential between the extremities of the arc, by a thermal voltmeter. 3. The apparent continuous current, by a tangent galvanometer in the circuit. 4. The apparent constant difference of potential between the electrodes, by a torsion galvanometer. 5. The instantaneous differences of potential between the electrodes at sixteen different phases of the current, by means of a commutator mounted on the shaft of the alternator, a condenser, and a ballistic galvanometer. 6. The current in the circuit simultaneous with the differences of potential measured in 5, by similarly measuring the instantaneous difference of potential between the ends of a resistance in series with the arc.

The curves obtained from 5 and 6 are not equally above and below the axis of abscissæ, and when integrated they give results in conformity with the readings on the ordinary galvanometers, confirming the presence of an excess of current in the direction from the metal through the arc to the carbon.

It is necessary to conclude that the formation of the arc in the direction carbon-iron meets with a great resistance, the nature of which is unknown. This resistance causes the current during that half-period to be almost zero, and the difference of potential between the electrodes to become almost equal to the E.M.F. of the alternator. In the other half-period the current passes without great resistance from iron to carbon, a continuous arc is obtained, and the difference of potential remains sensibly constant between 30 and 40 volts.

The behaviour of two such arcs in parallel, but with the electrodes in opposite directions in the two arcs, is also considered. In this case the curves obtained are symmetrical with respect to the axis.

Two carbons of different nature act to some extent like a metal and a carbon. J. B. H.

680. *Metal-Carbon Arcs.* **A. Blondel.** (Comptes Rendus, 128. pp. 727–731, 1899.)—All metals employed as electrodes in the presence of another electrode of carbon give rise to the same phenomena, and only present quantitative differences. In every case, two distinct phenomena appear in an alternating circuit thus constituted. They may be called the short arc and the long arc respectively. The former is only about 1 mm. long, and shows a certain diasymmetry between successive alternations, which is greater in the case of zinc and iron than in the case of copper and aluminium. On lengthening the arc, it begins to hiss, and the curves assume a different character. The long arc is characterised by the suppressions of the alternations on one side, since the current does not flow in the sense carbon-metal. The long arc is very unstable. In an inductive circuit the establishment of the long arc is accompanied by a sudden increase of mean intensity as indicated by the thermal ammeter. In the case of copper, the rise is from 9 to 20 amperes. This

is due to the fact that the metal-carbon currents are prolonged, and the area of curve of the squares of intensities is greater than the area of the two ordinary alternations. E. E. F.

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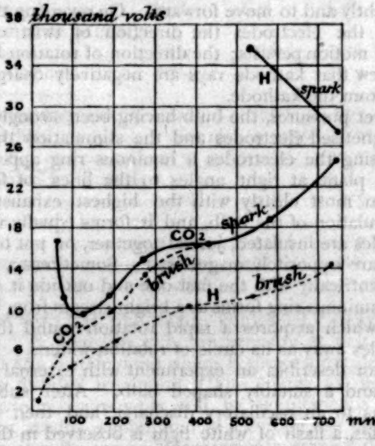
681. *Induction-Coil Discharges.* **A. Oberbeck.** (Wied. Annalen, 67. 3. pp. 592–607, 1899.)—The author adds to his former determinations of discharge potentials between spheres, points, and plates. He specially investigates the difference between spark discharges and brush discharges. He fixes two small brass spheres at a constant distance of 6 cm. apart, that being the minimum at which the two forms of discharge can be separately observed in the open air. On reducing the pressure between the spheres, the character of both discharges changes, but the author calls the spark discharge that which is attached to both electrodes. The results are shown in the annexed diagram for hydrogen and carbonic acid. Although the curves are so widely separated in the two cases, the author believes that they are essentially of the same character, and that on proceeding further to the right the two hydrogen curves would join as they do in the case of CO_2. This is confirmed by the fact that air shows curves intermediate in character. E. E. F.



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682. *Discharge Phenomena.* **N. Tesla.** (West. Electn. 23. p. 301, 1898.)—In the *New York Sun* for November 19,

1898, Tesla described his views on the possibilities of high-frequency and high-potential phenomena. This is a reprint of his article. It is for the most part conjecture. R. A.

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683. *Vacuum Tubes with Magnetised Electrodes.* **C. E. S. Phillips.** (Roy. Soc. Proc. 64. pp. 172–176, 1898.)—The vacuum tube is a soda-glass bulb, provided with pointed soft iron electrodes, which lie between the poles of a large electro-magnet and are insulated from the poles by thin sheets of glass. The bulb can be put into connection with a Sprengel air-pump, and no precautions are taken to exclude mercury vapour from the bulb. The pressure having been reduced until kathode rays begin to appear, the electrodes are then magnetised; this causes the fluorescence on the walls of the bulb due to the kathode rays to twist slightly and to move forward. On reversing the magnetic polarity of the electrodes the direction of twist changes, but the forward motion persists; the direction of rotation is consistent with the view that kathode rays are negatively charged particles streaming from the kathode.

With lower pressures, the bulb having been strongly stimulated with unmagnetised electrodes and the stimulation then stopped, on magnetising the electrodes a luminous ring appears between them in a plane at right angles to the lines of force. The ring is seen most clearly with the highest exhaustions which permit stimulation of the bulb, and it forms equally well whether the electrodes are insulated, joined together, or put to earth, provided they are oppositely magnetised. Sometimes a second ring forms concentrically with the first one and outside it. The inner and more luminous ring forms as a bright stream from between the electrodes, which acquires a rapid rotation round the magnetic axis and fades away as its circle of rotation widens.

The author describes an experiment with external magnetised electrodes and a suitably shaped bulb. After subjecting the enclosed gas to an oscillatory discharge and then magnetising the electrodes, a flash of white light is observed in the tube, and irregular green splashes momentarily appear on the glass.

J. L. H.

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684. *Energy Consumed in Vacuum Tubes.* **H. Ebert.** (Wied. Annalen, 67. 3. pp. 608–629, 1899.)—In estimating the energy consumed by vacuum tubes fed with alternating currents, direct-current measurements are not available, owing to the phase difference introduced by the capacity of the discharge tubes. The author therefore made some direct measurements with currents of high frequency (22,000 alternations per minute) transformed up to 3,000 volts. The form of the current curve, as tested by a Braun kathode ray tube, was very nearly sinusoïdal. The instru-

ments employed in the low-pressure circuit included a Cardew voltmeter, an alternate-current ammeter by Hartmann and Braun, and a Weston wattmeter. In the high-pressure circuit, a plate voltmeter and a hot-wire ammeter were employed. The energy consumed by the tube was determined from the watts consumed in the primary circuit, after deducting the heat developed in the primary, the hysteresis loss (about one watt), the loss due to capacity, and the heat developed in the secondary coil, when the tube becomes luminous. The consumption obtained gave a clue to the phase difference in the secondary circuit due to the influence of the tube. The following table shows some results obtained for nitrogen:—

Volts in primary circuit ...	30	29	30	30
Amperes in ditto	1·1	1·2	1·2	1·1
Watts in ditto	17·8	15·3[1]	16·3	26·4
Phase difference	57°	64°	63°	37°
Heat consumed in primary coil, watts.................	1·4	1·6	1·6	1·4
Energy transformed.........	15·4	12·7	13·7	24·0

Volts in secondary circuit	1023	776[1]	863	2100
Amperes in ditto	0·0116	0·0136[2]	0·0136	0·0116
$E = V_{eff} \times i_{eff}$	11·9	10·6[1]	11·7	24·4
Heat consumed in secondary coil	1·8	2·5	2·5	1·8
Watts consumed by discharge	11·1	7·7[1]	8·7	19·7
Phase difference	21°	43°[2]	42°	36°
Pressure in mm. Hg	2·92	0·82	0·45	0·10

It will be seen that the energy consumed closely follows the product E*i*. It decreases with the pressure at first, and reaches a minimum at a certain point where E shows a decided minimum, and *i* a less decided maximum. The energy, as indicated both by the above measurements and by simultaneous calorimetric observations, attains a minimum at a certain low pressure, which in nitrogen is 0·82 mm. Measurements carried down to very much smaller pressures show that, so far as luminous effects are concerned, they may be produced at a very small expense of energy indeed. The reversal in the consumption of energy occurs in the same tube at very different pressures, according to the gas contained in it. In one form of tube the reversal pressures were found to be the following: Hydrogen 1·26 mm., nitrogen 0·65, CO 0·65, air 0·60, CO_2 0·47. These pressures are inversely proportional to the mean free paths of the molecules at atmospheric pressure. Put in another form, it may be said that, for a given valency, the reversal takes place at higher pressure the larger the sphere of influence of the luminescent molecules; or, if the molecular diameters are the same, the reversal pressure is the higher, the smaller the number of ionic charges disengaged by a complete dissociation of the molecule. The gases with smaller free paths have a greater "dielectric strength" than those with large free paths. In other words, the dielectric strength of a gas increases with the valency of its molecules and the smallness of its sphere of influence. All the results obtained go to support the view according to which the luminous phenomena in vacuum tubes are due to dissociations brought about by the kathode rays impinging upon the gaseous molecules. The greater the valency of the molecule, the greater is the amount of energy required for its dissociation. E. E. F.

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[1] Minimum. [2] Maximum.

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685. *Duration of Kathode Phenomena.* **E. Wiedemann.** (Wied. Annalen, 67. 3. pp. 714–716, 1899.)—If a discharge tube, with or without electrodes, is brought into a slightly damped high-frequency field, pure kathode phenomena are seen at both ends, without any superposition of positive effects. Hence it has been concluded that the negative phenomena persist from one half-oscillation to the next (*i.e.*, for about 10^{-6} sec.), and so hinder the development of the positive effects. It remains to be decided whether the great fall of potential at the kathode which produces the deflection of the kathode rays also persists for some time. The author's experiments gave a negative answer to this question. He cemented a glass tube into a glass bulb, so that its closed end was in the centre of the bulb. The two knobs of a spark-gap, forming the terminals of a Lecher wire system, were pressed against the bulb at points not diametrically opposed. Each of them formed a kathode during a part of the oscillation, and produced a shadow of the tube, and a wire contained in it, on the opposite wall of the bulb. On joining one of the knobs with the wire, the rays proceeding from the other knob were deflected, and the corresponding shadow was broadened, owing to the slope of potential round the wire. This slope of potential disappeared during the next semi-oscillation, as was shown by the other shadow remaining sharp. E. E. F.

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686. *Deflections of Kathode Rays.* **D. F. Tollenaar.** (Wied. Annalen, 66. 1. pp. 83–87, 1898.)—The fact observed by Wiedemann (Wied. Annalen, 63. p. 248, 1897) that when the kathode consists of a strip of metal bent so as to form two portions at right angles to one another, a fluorescent screen placed in the angle shows two marginal regions of darkness and a mesial region of brightness bounded by a double caustic whose apex is at the angle, is explained thus: Each limb repels and thus deflects the rays from the other limb, the nearer rays most powerfully. The nearer rays thus cross the farther ones.

Similarly for the other limb of the kathode. The congeries of crossings accounts for the caustic observed. The reason of the repulsion is the negatively charged kathode particles crossing an electric field; and the potential gradient in such field is altered by changes in the amount of vacuum, so as to affect the amount of deflection. A. D.

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687. *Reflection of Kathode Rays.* **A. A. C. Swinton.** (Roy. Soc. Proc. 64. pp. 377-395, 1899).—The author finds that the rays which in a focus tube proceed from the front surface of the anti-kathode and cause the green fluorescence of the glass, have exactly the same properties as kathode rays, and are, in fact, reflected kathode rays. The mechanical force they exert on mill wheels is, however, inappreciable, and the inverse rotation of such wheels when outside the kathode stream (see 1899, Abstract No. 82) is not due to them, but to some other more potent cause. The reflection of kathode rays is largely diffuse; but with a concave reflector of polished platinum a certain proportion of the rays are reflected in true specular fashion. Some further rays of an unexplained description are given off normally to the surface of the reflector. Experiments with a tube fitted with a movable platinum reflector, and also with a Faraday cylinder, capable of rotation round the reflector, connected to an electrometer, show that the field of reflected kathode rays is not uniform, but increases on both sides to a maximum which, for all angles of incidence, always occurs at the point that makes the angle of reflection equal to that of incidence. As the incidence is made more slanting, the charge carried by the reflected rays increases, while the charge imparted to the reflector and the amount of Röntgen rays produced decreases. This supports the view that the Röntgen rays are actually due to the charges carried by the kathode ray particles being imparted to the anti-kathode reflector.

AUTHOR.

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688. *Slow Electric Oscillations.* **W. König.** (Wied. Annalen 67. 3. pp. 535-562, 1899.)—The author describes several new methods for the study of electric oscillations of periods approaching to those of sound waves. They are mostly based upon the principle of Lichtenberg's figures. When a resin plate is made to rotate instead of being stationary, and a spark discharge is led through it, a series of successive red and yellow figures is obtained on sprinkling it with sulphur and minium. Better defined figures are obtained when the surface is a metallic plate painted with asphalt varnish, and the conductor has a point made of a bad conductor, such as a piece of straw. A broken red-and-yellow line is thus obtained. This may be utilised for the measurement of the spark period by attaching the straw to the prong of a

tuning-fork, through which the discharge is led. Thus a wavy line is obtained, in which every oscillation is represented by a yellow or red section, and the number of waves in each section gives a direct measure of the period. The method thus becomes very accurate and valuable, and is applicable down to 20 volts, the errors not exceeding 1 per cent. The author has applied it to verify the laws governing the period of induction-coil discharges. E. E. F.

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689. *Electric Wire-Waves.* **W. D. Coolidge.** (Wied. Annalen, 67. 3. pp. 578–591, 1899).—A method is described of making the waves in a Blondlot wire system visible by the light effects from the wires, without enclosing the latter in long vacuum tubes, as proposed by Arons. To produce very strong oscillations, the secondary ring is placed just under the primary ring, being only separated by a mica plate, and the whole is immersed in petroleum. The parallel wires are 10 to 20 mm. apart, and their diameter is only 0·1 mm. The best source is an induction coil used with a Tesla transformer. The luminous wires are photographed, and the negatives reproduced show the successive nodes and ventral segments very well, "overtones" being clearly indicated in many cases. E. E. F.

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690. *Multiple Resonance of Electric Oscillations.* **L. Décombe.** (Annal. Chim. Phys. 15. pp. 156–202, 1898.)—This paper discusses the question as to whether a Hertzian oscillator emits electric waves forming a continuous spectrum (comparable to white light) or waves of only one frequency (analogous to monochromatic light). After reviewing the work done and hypotheses proposed by Sarasin and de la Rive, Garbasso and Aschkinass, and Zehnder in favour of multiple resonance, and the experiments of Wartz, Jones, Rubens, Bjerknes, and Perot, which support the single frequency view, the author gives details of his own arrangement to test the question by the revolving mirror method. He thus arrives at the conclusion that the apparatus emits a unique oscillation of well-defined period. The *apparent* multiple resonance observed by Sarasin and de la Rive is felt to be explainable only on the theory proposed by Poincaré in 1891 as to the rapid damping in the primary oscillator and comparatively slow damping in the resonator. (See also Phys. Soc. Abstracts No. 266, 1895.) E. H. B.

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691. *Modification of Hertz Resonator.* **A. Turpain.** (Écl. Électr. 17. pp. 73–78, 1898.)—A circular resonator containing a gap (in addition to the ordinary micrometric gap or spark-gap) works as well as a complete resonator. The two ends of the conductor (having the gap between them) are connected up with

a battery and telephone; whenever sparks cross the micrometer gap the circuit becomes closed and the telephone disc vibrates. Listening to the telephone is less fatiguing than watching the spark-gap. That the introduction of an auxiliary current does not alter the conditions may be shown by suppressing the battery. The Hertzian oscillation then actuates the telephone and the note heard is of the same pitch as when the battery is in, but is less intense. The author also states that the introduction of the telephone into the resonator circuit does not alter the results obtained. These are as follows :—

I. Influence of direction of sparks in micrometer :—Two resonators, identical excepting that in one the sparks are normal to the circumference of the resonator in its plane, whereas in the other they are tangential, give the same results. The action appears to be independent of the direction of the spark, excepting that the sparking distance is greater in the case of the normal micrometer.

II. Influence of a gap and its position :—The gap varies from 2 to 11 hundredths of the total length of the resonator; as explained above, this gap was in addition to the spark-gap as contained in an ordinary resonator. When the gap is in a symmetrical position the azimuths of extinction are as in an ordinary resonator. When the gap is asymmetric the azimuth of extinction or of minimum effect is such that the azimuth of extinction of an ordinary resonator would pass through the middle of the gap. In a gap-resonator the gap plays the *rôle* of the micrometer in the ordinary resonator.

III. Influence of the gap on the wave-length of a resonator :—The difference between the half-wave-length of an ordinary resonator and the half-wave-length of a gap-resonator of the same radius is equal to the length of the gap ($\lambda - \lambda_g = 2_g$). (See also 1898, Abstract No. 512.) D. E. J.

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692. *Coherers.* **T. Tommasina.** (Comptes Rendus, 127. pp. 1014–1016, 1898.)—A ball of nickeled brass 1 cm. in diameter is hung by a fine metallic wire above the centre of a horizontal copper disc 4 cm. in diameter; a pinch of nickel filings is placed on the disc, and the bob of the pendulum arranged so as just to graze them. This forms an elementary coherer which is put in circuit with a condenser, a resistance, and a very sensitive relay which opens and closes another circuit containing a resistance box, two condensers, and a small incandescent lamp. At each spark of an oscillator at the other end of the room, the lamp glows: the slightest movement of the pendulum extinguishes it. When the disc is lowered slightly there is formed between it and the bob a single thin chain of glowing filings, along which the current continues to pass; with care a chain 2 cm. long can be

obtained. On trying different metals and alloys, it is found that the effect is inversely proportional to the oxidisability of the substance. G. B. M.

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693. *Coherers of Gold and Platinum.* **E. Branly.** (Comptes Rendus, 127. pp. 1206–1207, 1898.)—The author attributes the failure which some experimenters have had with these metals to want of sufficient care in establishing the necessary slight initial contact. He confines the filings in a tube between two plates, one of which has a screw adjustment with which the slight contact is established. The following example of the sensitiveness of a coherer with gold filings is given :—

The coherer is entirely enclosed with its relay and bell circuit in a metal case, the only opening in which is a vertical slit 20 cm. × 1 mm. A Ruhmkorff coil, 25 mm. spark with 4 volts, is placed at 20 m. distance, each terminal being connected to a horizontal brass cylinder 45 mm. diam. and 15 cm. long. The two cylinders have the same axis and terminate in spheres whose surfaces are placed 1 mm. distant. The 1 mm. spark between these balls at once makes the coherer conduct, and a slight shock re-establishes the resistance. J. B. H.

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694. *Measuring High Electric Pressures.* **W. Peukert.** (Écl. Électr. 17. pp. 332–333, 1898; Elektr. Zeitschr. 19. p. 657, 1898.) —For measuring high alternating potential differences, the author connects a number of condensers of equal capacity in series across the terminals whose potential difference is to be measured, and then measures the potential difference across the terminals of one of them. The required value is obtained by multiplying the observed value by the number of condensers in series. In an example, the apparatus consisted of 10 mica condensers, as equal as possible, arranged in a box. The surface was 135 sq. cms. They were separated by plates of paraffined wood connected together by screws. The small differences between the several condensers were exactly compensated for by varying the pressure of the wood plates. The capacity of each condenser is 0·00607 microfarad. Terminals are provided to enable any desired number of condensers to be used in series or in parallel. Other methods of proportionately reducing the potential difference to be measured, by transformers and by resistances without self-induction, are also discussed. C. K. F.

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695. *Measurement of Current Leakage.* **M. Kallmann.** (Electrician, 42. pp. 303–305, 1898; also Elektrotechnische Zeitschrift, Oct. 13 and 20, 1898.)—This method of measuring current leakage is based on the fact that if two ammeters be put

into a main or lead the difference between their readings indicates the leakage current between them. The method is carried out in practice by inserting two equal resistances at the two points between which the leakage is to be measured and connecting the ends of one resistance to one coil of a differential galvanometer, the ends of the other resistance being connected to the other coil. The deflection in the galvanometer will then be a measure of the leakage between the two points. Instead of a differential galvanometer, four equal resistances (in addition to the two before mentioned) and an ordinary galvanometer may be employed, the arrangement being similar to that in Kelvin's double bridge. The author treats of the application of this method: (*a*) to measure the leakage in a single feeder; (*b*) to indicate the currents returning through earth from the rails of an electric railway; (*c*) to show the whole leakage current from a two-wire system; (*d*) ditto from a three-wire system; (*e*) to measure the leakage currents from transmission lines to sub-stations.

E. C. R.

696. *Measurement of Inductance.* **S. T. Moreland.** (Amer. Assoc. Proc. 47. pp. 121–122, 1898.)—Two coils are placed at right angles, and in the space inside them is suspended a hollow copper cylinder used with a mirror, lamp, and scale. If each coil is placed in one branch of a divided circuit carrying an alternating current, a rotary field will in general be produced, and the suspended cylinder will turn until the torque of the suspension equals the torque due to the rotary field. When, however, the time constants of the two branches are equal, the currents will be in phase and no rotary field will be produced, hence the cylinder will not be deflected. If the resistances of the two branches is known and also the inductance of one of them, the inductance of the other can be calculated from the formula $L_2 = L_1\ r_2/r_1$. L_1 and L_2 being the inductances in series with the coils, plus the inductances of the respective coils themselves, which must be known, and r_1 and r_2 the resistances of the corresponding branches. A balance is best obtained by the adjustment of the resistances.

E. C. R.

697. *Bridge Method of Comparing Low Resistances.* **H. L. Callendar.** (Electrician, 41. p. 354, 1898.)—The author criticises the use of 10,000 ohm coils instead of a slide wire. The bridge is preferable to potentiometer in that the testing current may be smaller and need not be kept constant. He also criticises Kelvin's double bridge, of which the connections are complicated and liable to thermoelectric troubles from being asymetric. An instance is given of a calibration in a power house of two 10,000 ampere shunts.

M. O'G.

698. *Polarisation under Pressure.* **A. Chassy.** (Comptes Rendus, 127. pp. 1203–1205, 1898.)—Cailletet and Collardeau have shown that an electrolytic cell (having electrodes of spongy platinum) in which a current has been passing, has its capacity of polarisation enormously increased by external pressure. The author of this paper has investigated whether the initial capacity of polarisation is also increased by the pressure; that is to say, whether the charge produced by a very small E.M.F. increases with the pressure.

Polished plates of various metals and also spongy platinum were used as electrodes. Water acidulated to different degrees and saline solutions formed the electrolytes. Pressures up to 2,000 atmospheres were used. In every case the initial capacity of polarisation was found to be practically independent of the pressure, the variations obtained being all such as could be accounted for by other causes quite independent of the pressure. J. B. H.

699. *Polarisation under Pressure.* **R. Federico.** (N. Cimento, 8. 4. pp. 409–419, 1898.)—Similar results to those obtained with sulphuric acid (see 1899, Abstract No. 466); but with a 10 per cent. solution of nitric acid the maximum E.M.F. of polarisation rises 0·035 volt under 900 atmospheres, and with a 10 per cent. solution of hydrochloric acid 0·038 volt under 995 atmospheres, as against a rise of 0·113 volt with an 8 per cent. solution of sulphuric acid under 900 atmospheres pressure. The variations of the maximum E.M.F. of polarisation with the pressure are more rapid at lower pressures than at high, in nitric acid as in sulphuric acid solutions, but less markedly so; in hydrochloric acid solutions these variations are practically constant at all pressures. A. D.

700. *Polarisation.* **W. A. Anthony.** (Amer. Assoc. Proc. 47. pp. 138–140, 1898.)—The author investigated the polarisation of simple cells in which copper, carbon, or platinum was opposed to zinc in sulphuric acid. The cells were closed through resistances, and the recovery observed when hydrogen, nitrogen, or oxygen was passed through the electrolyte. The author arrives at the conclusion that the high initial E.M.F. of a cell is due to dissolved oxygen, so that the negative plate is really an oxygen plate. The polarisation is not due to hydrogen on the plate but to exhaustion of oxygen in the electrolyte. Contrary to the opinion of Le Blanc, the author holds that platinum is not an inert metal. W. R. C.

701. *Thermoelectric and Galvanic Action.* **C. J. Reed.** (Frank. Instit. Journ. 146. pp. 424–448, 1898.)—A comparison

of thermoelectric and galvanic action. The author uses the term thermoelectric to include any process in which the electrical energy is derived entirely from external heat. Some examples are given of cells which might appear to be galvanic but are really thermoelectric. Among these is included the Jacques cell. **A. E. Kenelly** pointed out in the discussion that efficiency forms a criterion by which galvanic action may be judged, and was of the opinion that a cell depending upon heat for its energy, like the Jacques cell, was not necessarily thermoelectric. Experimental evidence was required. **J. W. Richards** expressed the opinion that ordinary thermochemical data do not apply at the temperature of the Jacques cell; if such were available it would be recognised that the cell is purely chemical. W. R. C.

702. *Electrothermal Relations.* **F. Kohlrausch.** (Wied. Annalen, 67. 3. pp. 630–632, 1899.)—The author refers to Riecke's discussion of the relations between thermal and electrical conductivity (see 1899, Abstract No. 299), and maintains that his own way of presenting the same relations does not involve any complexity. E. E. F.

703. *Galvanometers.* **W. E. Ayrton** and **T. Mather.** (Phil. Mag. 46. pp. 349–379, 1898.)—This third paper comprises three sections: A contains two lists of sensitive galvanometer records, reduced to the standard conditions of 10 seconds period, scale distance = 1,000 scale divisions, resistance of instrument 1 ohm. The most sensitive instruments, according to the authors' criteria, are two Paschen galvanometers, and one of the Nichols type. Table IV. gives results for oscillographs, and V. VI. relate to d'Arsonval galvanometers. Section B discusses the limiting sensitiveness of Thomson galvanometers; C the comparative merits of long and short period instruments for zero methods. The authors conclude that, when practicable, the rule for rapid working is "adjust the control so that the sensitiveness is, say, two or three times as great as is absolutely necessary for the desired accuracy." G. B. M.

704. *Sensitiveness of Movable-Coil Galvanometers.* **C. Féry.** (Comptes Rendus, 128. pp. 663–666, 1899.)—Having occasion to measure very small currents by means of a Depretz-d'Arsonval galvanometer, the author determined the ratio $\frac{r'}{r}$ of the resistances of the torsion wire and the coil which produces maximum sensitiveness in the galvanometer. As usually constructed, the resistances referred to are $r' = 0{\cdot}5$ ohms and $r = 200$ ohms. If $r + r'$ is to remain the same, the maximum deflection is obtained

when $r' = 2r$. Hence we must have $r' = 132$ ohms and $r = 66$ ohms. This increases the sensitiveness 153 times. But it must not be thought that a simple application of the formula leads direct to such an easy augmentation of the sensitiveness. Several disturbing causes intervene, the most important of which is the magnetism of the copper of the coil. This can be eliminated either by employing a perfectly uniform field or by making the permeability of the moving coil equal to unity by furnishing it with diamagnetic bodies. E. E. F.

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705. *General Electric Company's (U.S.A.) Wattmeter for Triphase Currents.* **J. W. Blackstone.** (Écl. Électr. 17. pp. 483–484, 1898.)—In this wattmeter an aluminium disc is arranged to rotate between two pairs of pole-pieces arranged diametrically opposite each other. The cores on which these pole-pieces are formed are wound with shunt coils placed respectively across conductors 1 and 2, and 2 and 3, for example, the inductance of each shunt being increased by arranging in series therewith an inductive coil wound on a core forming part of a closed magnetic circuit; the currents in the shunt coils are thus retarded by 90°. Series coils in conductors 1 and 3 are arranged in pairs by the side of each of the shunt coils, the two systems being arranged sufficiently far apart to prevent them from interfering with each other. Between the two systems are arranged two diametrically opposite brake magnets. This meter is independent of temperature variations and gave very good results when tested. C. K. F.

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706. *Tudor's Electromagnetic Contact Breaker.* (Écl. Électr. 17. pp. 447–448, 1898.)—A closed glass tube of special form contains mercury which in one position of the tube makes electric contact between two platinum electrodes sealed through the tube. The tube is mounted on the armature of an electromagnet in such a manner that when the armature is attracted the mercury flows to another part of the tube and breaks the contact. The tube is exhausted or contains a gas which does not act on mercury, and is shaped so that the spark takes place between two surfaces of mercury. J. B. H.

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707. *Unpolarisable Electrodes.* **E. Warburg.** (Wied. Annalen, 67. 3. pp. 493–499, 1899.)—Starting from the equation—

$$p = \frac{a}{C\,m} \sin\left[mt - \left(\frac{\pi}{2} - \psi\right)\right]$$

giving the polarisation p in terms of the polarisation capacity C, for alternating currents, the author calculates the polarisation capacities of certain "unpolarisable" electrodes such as mercury in sulphuric acid saturated with mercuric sulphate, or silver in silver nitrate solution. In the latter case, if the second electrode can be considered infinite, and if the concentration at its surface is 1 gr. equiv. in 1,000 litres, the capacity of the first electrode per sq. cm. at a temperature of 18° C. and for the case of $m = 200{\cdot}2\pi$ is 664·8 microfarads. This agrees well with experimental values.

Part of the polarisation is probably due to the solution of electrode metal in the electrolyte, which contains oxygen, since the current produces a change of concentration in this salt. If it is altogether due to this cause, C must be inversely proportional to the square root of the frequency, and ψ must be $=\pi/4$. This is fulfilled in the cases mentioned above, and approximately in the case of platinised platinum electrodes in NaCl solution, but not in the case of mercury or smooth platinum electrodes in aqueous solutions of salts of the lighter metals. Their anomalous behaviour should be investigated. E. E. F.

708. *Reversible Electrodes.* **E. Neumann.** (Wied. Annalen, 67. 3. pp. 500–534, 1899.)—The authoress investigates theoretically and experimentally the polarisation capacity of electrodes immersed in a very dilute solution of their own salt, a more concentrated solution, having the same anion, being inserted between the two electrodes. Electric currents and diffusion produce displacements of concentration in the electrolyte, and these again produce polarisation of the electrodes. The capacity of polarisation is, by Warburg's theory—

$$C = \frac{c_0 \sqrt{k}\, q\, \epsilon^2\, w}{2R\, \theta \sqrt{m}\, f}$$

where c_0 is the initial concentration, k the diffusion constant ϵ the charge of a gramme-ion, w the valency of the metal, R the gas constant, θ the absolute temperature, and f the number of ions liberated by the dissociation of a molecule. The authoress tests the dependence of C upon (1) the frequency, (2) the concentration, (3) the current intensity. She also finds the absolute value of the phase displacement and of the capacity itself, and investigates the relation between the resistance and the frequency. The theoretical relations (1) and (3) are found to hold good in mercury, and approximately in silver, but (2) only up to certain concentrations. The absolute value of the phase-difference agrees best in the case of mercury, and that of the capacity in the case of silver. E. E. F.

709. *Distributed Capacity in Alternating Current Circuits.* **C. F. Guilbert.** (Écl. Électr. 17. pp. 177–186, 1898.)—This article is too long and complicated to admit of a comprehensive abstract.

The method of imaginary quantities is used, and the problem resolves itself into the solution of a differential equation of the second order in which the variable time is absent. In concluding the article the author remarks that the use of imaginary quantities considerably simplifies the solution of the problem of uniformly distributed capacity. The method may be used to successfully attack some problems which would be very difficult, if not impossible, to attack by ordinary methods. W. G. R.

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710. *Blondel-Carpentier Hysteresis Tester.* **Armagnat.** (Ind. Élect. 7. pp. 543–546, 1898.)—The specimen to be tested takes the form of circular discs having an external diameter of 55 mm., and an internal one of 38 mm., the number of discs being chosen so as to make up a total thickness of 4 mm. These discs are suitably supported on a vertical spindle provided with a pointer and helical spring, the latter being enclosed in an oil vessel which provides the necessary damping. A powerful U-shaped permanent magnet provides the field, the discs being placed between its poles. The air-gap is made sufficiently large to render the magnetic reluctance of the specimen negligible in comparison with it. When the magnet is rotated, the deflection of the pointer attached to the spindle supporting the discs affords a measure of the hysteresis loss. The instrument obviously measures the hysteresis loss in a *rotating* field. But by using a different form of support for the specimen, and giving the latter the form of rectangular strips, the loss in an *alternating* field may be determined as in the Ewing instrument. A. H.

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711. *Effect of Silicon on Permeability of Cast Iron.* **F. C. Caldwell.** (Elect. World, 32. p. 619, 1898.)—The author gives B–H curves for specimens of two brands of iron ("Rockford" and Bessemer) containing different amounts of silicon, and from these it appears that the addition of silicon, between the limits of 1·8 and 4·6 per cent., always increases the permeability, the increase following the straight-line law; this result holds up to about 3·5 per cent. of silicon for inductions up to 8,000. The following data, which refer to the "Rockford" iron, and which do not differ materially from those for the Bessemer iron, are taken from the curves accompanying the paper:—

B=	2,000		5,000		7,000		8,000	
% of silicon	1·8	4·4	1·8	4·4	1·8	3·4	1·8	3·4
H=	13	3·5	32·5	14	65	44	94	63

A. H.

712. *Magnetic Properties of Sheet Iron.* **W. Rohr.** (Elektrotechn. Zeitschr. 43. p. 712, 1898, also Écl. Électr. 17. pp. 448–449, 1898.)—Koepsel's method of tracing the curves of magnetisation is used and the results of a number of experiments are given. The losses per cycle by hysteresis and by Foucault currents are tabulated for maximum inductions varying from 2,000 to 9,000 c.g.s. The coefficient of Steinmetz over the same range is also given, and is practically constant.

J. B. H.

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713. *Plane Magnetisation of Pyrrhotine.* **P. Weiss.** (Comptes Rendus, 126. pp. 1099–1100, 1898.)—Pyrrhotine or magnetic pyrites is, like magnetite, a crystalline magnetic substance. The crystals are of hexagonal appearance, but less symmetrical. They are somewhat rare, and the finest come from Brazil.

The author finds that on bringing a crystal near a magnet the attraction is nil when the plane of the hexagonal base is presented normally to the lines of force, whereas the attraction is most marked for other orientations. There is, therefore, a direction in which magnetisation becomes impossible, and one is led to believe that the substance can only become magnetised in the plane which is perpendicular to this direction, which for the sake of brevity the author names the magnetic plane.

The author has carefully studied this property by means of induction experiments carried out by the ballistic method.

When compared to Brazilian pyrrhotine the pyrrhotines of other districts are weakly magnetic, and must be classed among magnetic substances of a different kind. The author is of opinion that a closer study of these substances will show that this property of magnetisation, reduced to one plane, can be applied to all the pyrrhotines. L. J. S.

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714. *Magnetostriction.* **H. Nagaoka** and **K. Honda.** (Phil. Mag. 46. pp. 261–290, 1898.)—This paper deals with (*a*) measurement of change of volume and length by magnetisation; (*b*) measurement of the effects of hydrostatic and transverse pressures and of longitudinal pull on magnetisation; (*c*) calculation of Kirchhoff's coefficients k', k'', and a comparison of theory and experiment.

The subjects of the experiment were an ovoid of Swedish iron, a cylinder of Lowmoor iron, and a nickel rod of square cross-section.

The experimental results are:—

1. Hydrostatic pressure produces decrease of magnetisation in iron.

2. Magnetisation in iron produces increase of volume.

3. Hydrostatic pressure produces small increase of magnetisation in nickel.

4. Magnetisation produces small decrease of volume in nickel.

5. In moderate fields the application of a longitudinal pull produces in iron an increase of magnetisation up to a critical value, after which it decreases until it is less than when the iron is unstretched.

6. Magnetisation produces increase of length in iron till it reaches a maximum when H is about 30, after which it gradually diminishes.

7. In moderate fields a longitudinal pull produces decrease of magnetisation in nickel up to a critical value, after which it gradually increases, but does not attain a value greater than when the nickel is unstretched.

8. Magnetisation produces continuous diminution of length in nickel.

The only serious discrepancy between theory and experiment occurs in 1. The result 4 is also discordant; but here the effects deduced from theory are so small as to fall within the range of experimental errors.

Illustrative diagrams and numerical tables accompany the paper. G. B. M.

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715. *Magnetic Susceptibility of Water.* **G. Jäger** and **S. Meyer.** (Wied. Annalen, 67. 2. pp. 427–429, 1899.)—An attempt is made to discover the cause of the discrepancy between the authors' value for the susceptibility of water and the values arrived at separately by du Bois ($-0{\cdot}837 \times 10^{-6}$ at 15°) and Koenigsberger ($-0{\cdot}79 \times 10^{-6}$ at 15°), who both used Quincke's method of capillary elevation. The discrepancy, however, remains unaccounted for, the value obtained after eliminating every conceivable source of error being $-0{\cdot}687\,(1 - 0{\cdot}0016t)\,10^{-6}$.

E. E. F.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

716. *Microstructure of Alloys.* **J. E. Stead.** (Soc. Chem. Ind. Journ. 17. 1111–1116, 1898.)—Antimony and Tin.—The eutectic alloy containing 7½ per cent. of antimony is a mixture of tin and the compound SnSb; its crystalline structure resembles that of tin. With larger proportions of antimony (up to about 40 per cent.) the compound SnSb separates out in what appear to be cubes embedded in the first-mentioned eutectic. From 57 to 100 per cent. of antimony crystals of this metal are found in a matrix of undecided composition. Between 40 per cent. and 57 per cent. of antimony the crystals are apparently transition products between SbSn and Sb.

Antimony and Copper.—These alloys are classified as follows: From 100 to 75·8 per cent. of antimony the alloys consist of crystals of antimony embedded in the eutectic alloy of antimony and the purple compound $SbCu_2$ containing 75·8 per cent. Sb and 24·2 per cent. Cu. From 75·8 to 48·5 per cent. of antimony, crystallites of $SbCu_2$ are found in increasing quantity, until finally a homogeneous ~~mass~~ of $SbCu_2$ is reached. From 48·5 to 38·57 per cent. of Sb the purple compound is gradually displaced by white crystals, which appear to be $SbCu_3$. From 38·57 to 31 per cent. of Sb (which latter appears to be a second eutectic) the phenomena do not admit of a simple interpretation. When the proportion of Sb is less than 31 per cent., definite yellow crystals appear, containing increasing proportions of copper, apparently most concentrated in the central parts of the crystal.

Copper and Tin.—The crystallites of apparently indefinite composition found in alloys containing from 3 to 34 per cent. of Cu contain two constituents, one of which is probably CuSn. T. E.

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717. *Etherion.* **W. Crookes.** (Chem. News, 78. pp. 221–222, 1898.)—It is surmised by Crookes from his former researches that the "new gas," first announced by C. F. Brush (see 1899, Abstract No. 325) at the Amer. Assoc. for Adv. of Sc., Boston, August 23, 1898, may be simply aqueous vapour. In 1873 he noticed that a little of this vapour thrown into the vacuum converted into attraction the repulsion produced by radiation (Phil. Trans. clxiv. 2, p. 515). In 1876 he described experiments confirming this result (Ibid. clxvi. 2, p. 329), which he more fully investigated in 1880–81 and 1886. He found that air-dry glass condenses on its surface a considerable amount of water and CO_2 which does not come off in vacuo till heat is applied, and that if the heat be raised with intervals of exhaustion, the vapours are continually evolved until the bulb collapses, when

the fused glass shows minute bubbles due probably to escaping vapour of water. Similarly, etherion is stated to be "absorbed by glass and re-evolved on heating in vacuo" (Chem. News, lxxviii., p. 197). Extracts are given from unpublished work, proving that, at high vacua, aqueous vapour, like "etherion," is a better conductor than air or H at the same pressures, while Brush has also found that his new gas is absorbed by phosphoric anhydride and by soda-lime. S. R.

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718. *Predictions of Neon.* **W. Sedgwick.** (Chem. News, 78. p. 293, 1898.)—The existence of a non-valent element of the at. weight of neon, alluded to as theoretically probable by Lord Lister (Roy. Soc., November, 1898), had been predicted earlier by the author (Chem. News, lxxi., p. 139; Force as an Entity, 1896, p. 61; Roy. Soc., November, 1892), from a consideration of the series:—

$$F^{\text{I}}, 19; O^{\text{II}}, 16; N^{\text{III}}, 14; C^{\text{IV}}, 12.$$

He had also suggested that the metallic series

$$Na^{\text{I}}, 23; Mg^{\text{II}}, 24; Al^{\text{III}}, 27$$

pointed to a non-valent *metal* of the at. weight 20. He believes that in non-valent elements the form of the atom is a perfect sphere, and for valent atoms a sphere "with flat places in number corresponding with valency." "In the metalloid the flat places are cut down, so that the at. weight decreases as valency increases; in the metal they are built up" with the reverse effect, hence "the same non-valent element can give rise to both a metalloid and a metal series." J. Thomsen supports these conclusions from electrical considerations (Zeit. f. Anorg. Ch. ix. 28). With regard to Clerk-Maxwell's objection that the hard atom "fails to account for the vibrations of the molecule as shown in the spectroscope" (Art. "Atom," Encycl. Brit. 9th ed.), it is pointed out that, with an ether composed of two fluids, it is not necessary to refer the disturbance which gives rise to light to any vibratory movement in the atom. S. R.

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719. *Vapour Pressure of Co-existent Phases.* **M. Cantor.** (Wied. Annalen, 67. 3. pp. 683–689, 1899.)—If two liquids are mutually soluble to a limited extent, and the two saturated solutions are brought into contact, there is no mutual action. They form coexistent phases. An example is furnished by a saturated solution of ether in water and another of water in ether. Konowalow maintained that their vapours possess the same composition and the same vapour pressure. The author shows that

the experiments and considerations upon which that conclusion is based are inconclusive, and that the concentration of a body is greater in the vapour from the phase which contains it as a solvent. E. E. F.

720. *Vapour Pressure of Crystallised Hydrates.* **G. Tammann.** (Zeitschr. Phys. Chem. 27. pp. 323–336, 1898.)—The author describes some more substances in which the vapour pressure changes in a continuous manner with the composition. Among these are omelinite from Victoria, chabasite from Faroer, okenite from Greenland, and pyrophyllite from Zermatt. Some uncrystallised substances, such as wood, albumen, and the zeolites, have the same property. Wood may be reckoned physically among the solid solutions, but gelatine and soap must be considered as very viscous liquid solution. E. E. F.

721. *Molecular Weight of Liquids.* **D. Berthelot.** (Comptes Rendus, 128. pp. 606–609, 1899.)—By a combination of the results of Mathias with those of Amagat, the author arrives at the following formula, giving the molecular weight M of a liquid in terms of its density d at a temperature T, its critical temperature T_c, and critical pressure P_c (atmospheres):

$$M = 11{\cdot}4d\frac{T_c}{P_c\left(2 - \dfrac{T}{T_c}\right)}$$

Tables of the calculated and observed molecular weights of 42 liquids are given, including chlorides, benzene derivatives, propyl, butyl, and ethyl salts, and the differences range from 1 to 5 per cent. The conclusion arrived at is that the great majority of bodies have the same molecular volume in the liquid and in the gaseous state. Only water and the fatty acids and alcohols are distinctly polymerised. E. E. F.

722. *Osmotic Pressure and Thermodynamics.* **N. Schiller.** (Wied. Annalen, 67. 2. pp. 291–306, 1899.)—A mathematical investigation of the change of vapour pressure by external pressure on the surface; the heat of dilution; and the heat of solution of a gas absorbed by a liquid. E. E. F.

723. *Diffusion of Gases in Liquids.* **G. Hüfner.** (Zeitschr. Phys. Chem. 27. pp. 227–249, 1898.)—In a previous paper (see

Phys. Soc. Abstracts, No. 149, 1897) the author showed that plates of hydrophane could be used to stop the ends of tubes containing the liquid into which the gas is to diffuse, thus preventing convection currents in case the liquid gets heavier by absorbing gas. He has since applied a similar method to the determination of the rate of diffusion of ammonia in water, for which Müller found an altogether anomalous value, four times the rate of hydrogen. Since the amount of gaseous ammonia contained in a capillary tube 1 m. long is only about one-eighth of the amount which a thread of water 1 cm. long is capable of absorbing, Stefan's capillary method is altogether excluded. The author employs a siphon-shaped tube attached to a U-tube. The latter serves as a manometer, and also contains a bulb to hold the gas. The former is narrower, and its outside arm is closed at the lower end with a plate of hydrophane, which acts as a support for a short water column. The coefficient of diffusion thus obtained is 1·250 at 20°, and 0·822 at 5°, which agrees well with Voigtlander's figures, and is even less than the theoretical value deduced from the density.

The author also describes experiments made with gases diffusing through agar-agar. E. E. F.

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724. *Solubility of Salts of Weak Acids in Stronger Acids.* **A. A. Noyes** and **D. Schwartz.**—(Zeitschr. Phys. Chem. 27. pp. 279–284, 1898.) The solubility of silver benzoate in pure water, and in solutions of nitric and chlor-acetic acids is measured and found to be in complete agreement with the theory developed by Noyes (Zeitschr. Phys. Chem. 27, p. 267, 1898). In all cases the product of the concentrations of the Ag and $C_6H_5CO_2$ ions remains constant. T. E.

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725. *Dissociation of Water.* **R. A. Lehfeldt.** (Zeitschr. Phys. Chem. 27. p. 94, 1898.)—The 10×10^{-27} gram-mol. of hydrogen per litre which Luther calculates, from measurements of E.M.F., to exist in saturated steam at 20° would correspond, according to the kinetic theory, to *one* molecule of hydrogen in 80 litres. The fundamental assumptions made in the calculations require examination. T. E.

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726. *Solubility and Heat of Formation of Electrolytes.* **G. Bodländer.** (Zeitschr. Phys. Chem. 27. pp. 55–74, 1898.)—Calling E, the minimum E.M.F. required to decompose the saturated solution of a salt, E_a and E_k the E.M.F.'s required to separate its anion and kation respectively from their normal solutions, and *c* the concentration of the ionised part of the

salt in its saturated solution (measured in equivalents per litre), $E_s = E_a + E_k - k \log c$. When both ions are monovalent $k = 0{\cdot}116$, for one ion monovalent and the other divalent $k = 0{\cdot}087$, and for both ions divalent $k = 0{\cdot}058$. E_s may be calculated approximately from the heat of formation of the salt, preferably from solid constituents, since this is almost independent of temperature and therefore probably nearly equal to the free energy. For most sparingly soluble salts, c may be regarded as equal to the solubility. The values of the solubilities of a large number of salts calculated in this way from the existing, somewhat inaccurate, data, are always of the same order of magnitude as the observed solubilities, the concordance being in some cases close. The empirical rules that the solubility of different salts of the same metal (or acid) is greater, the greater the tendency of the acid radical (or metal) to pass into the ionised condition are in full agreement with the above equation, and the exceptions to these rules, are shown to be necessary consequences of it. T. E.

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727. *E.M.F. between Amalgams.* **H. P. Cady.** (Journ. Phys. Chem. 2. pp. 551–564, 1898).—The author has verified the conclusion that the E.M.F. of amalgam cells is independent of the solvent and concentration of the solute, but varies inversely as the valency of the metal in the electrolyte. With amalgams of the alkalies and alkaline earths abnormal results are obtained which are in harmony with Ramsay's observations on the vapour pressures of these amalgams. The value of an E.M.F. is given in general by the Helmholtz equation: in the case of amalgam cells, the heat of reaction is assumed to be zero, and the E.M.F. to be consequently given by the temperature coefficient only. The author finds that the heat of reaction cannot always be neglected, because the heat of dilution is sometimes considerable. When this is taken into account, the above results probably become normal: in the case of sodium, this view was shown experimentally to be correct. The van't Hoff-Raoult formula, $n/N = RT \log (p/p_1)$, holds theoretically only when the heat of dilution is zero. The equation for concentration cells should be written $E = q \times 0{\cdot}0002 \frac{T}{n} \log_{10} \frac{c_1}{c_2}$, in which q is the heat of dilution. W. R. C.

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728. *Liquid Cells and Ionisation of Fused Salts.* **C. McC. Gordon.** (Amer. Acad. Proc. 33. pp. 59–68, 1898.)—The author has measured the E.M.F. of liquid cells consisting of silver electrodes dipping into "solutions" of different concentrations of fused silver nitrate. The solvent was a mixture of fused potassium and sodium nitrate. In the cases where the concen-

tration of the silver nitrate was small, the actual results agree with those calculated from the Nernst formula, which is usually applied to cells containing aqueous solutions. As the concentration is increased, there is a marked divergence, which the author explains by assuming that the salt is not completely ionised. Regarding this divergence as a measure of the incompleteness of ionisation, the author concludes from measurements made upon a cell containing 100 per cent. and 50 per cent. "solutions" respectively about the electrodes that pure fused silver nitrate is ionised to the extent of 58 per cent. W. R. C.

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729. *Heat of Solution and Solubility of Electrolytes.* **J. J. van Laar.** (Zeitschr. Phys. Chem. 27. pp. 337–342, 1898.) The author replies to Noyes' criticisms. (See 1899, Abstract No. 149.) T. E.

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730. *Heat of Solution, Ionisation, and Solubility of Electrolytes.* **A. A. Noyes.** (Zeitschr. Phys. Chem. 28. pp. 431–438, 1899.)—A continuation of the above discussion with van Laar. Incidentally the following expression for the heat of ionisation of an electrolyte following an empirical law of dilution $\frac{x^{\nu}}{(1-x)\,v^{(\nu-1)}} = \mathrm{K}$, is obtained :—

$$\frac{\mathrm{Q}}{\mathrm{RT}^2} = \frac{n-1}{\nu-1} \cdot \frac{d \log \mathrm{K}}{d\mathrm{T}},$$

where x is the fraction of the salt ionised and n the number of ions into which it dissociates, ν an empiricial exponent and Q the heat of ionisation. T. E.

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731. *Ionising Power of Solvents.* **L. Kahlenberg** and **A. T. Lincoln.** (Journ. Phys. Chem. 3. pp. 12–35, 1899.)—The ionising powers of solvents run parallel, according to Nernst, with their dielectric constants; according to Dutoit and Aston, the molecular association, and according to Brühl the presence of elements possessing unsaturated valencies conditions dissociative power. Qualitative observations on the presence or absence of conductivity in solutions of $FeCl_3$, $SbCl_3$, $BiCl_3$, and $HgCl_2$ in 72 organic solvents show that, with one or two exceptions, Nernst's rule is in agreement with the facts. On the other hand, solutions in many non-polymerised solvents conduct well, whilst those in solvents having unsaturated valencies frequently do not. Quantitative determinations indicate more or less electrolytic dissociation; in some cases chemical action occurs between solvent and dissolved substances. Cryoscopic determinations with nitrobenzene as solvent give molecular weights above the theoretical values for $FeCl_3$, $SbCl_3$, and $SnCl_4$, below them for $AsCl_3$, $BiCl_3$,

and PCl_3. The fact that a solution of picric acid in benzene is a non-conductor is against Konowalow's view that combination of solvent and solute conditions conductivity. T. E.

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732. *Ionic Migration in Dilute Solutions.* **W. Bein.** (Zeitschr. Phys. Chem. 27. pp. 1–54, 1898.)—The most important source of error in determinations of the relative velocity of the ions by means of measurements of the changes of concentration at the electrodes is the diffusion of the products formed by the electrolysis away from the electrodes under the influence of the electric current. A very complete discussion of this source of error is given. The ordinary diffusion of the products of electrolysis into the solution is very slow and quite unimportant compared with the electrolytic diffusion. The presence of membranes influences the velocities of different ions to a different extent, and is therefore inadmissible in accurate determinations. Solid particles deposited near the electrodes are somewhat rapidly distributed by the current throughout the solution, and may render the results erroneous. When a cadmium anode is used a film of basic cadmium salts may be formed on it, making the concentration of the anode solution too small. Several other minor sources of error are discussed and five different forms of apparatus described. In these the anode and kathode solutions are kept separate by placing them sufficiently far apart. The principal results of the 174 determinations made are as follows (n is the transference ratio for the anion):—

HCl. Within the limits of experimental error n is independent of the concentration from 1/200 N to 1/5 N; its value at temperature t° is $n_t = 0{\cdot}157 + 9 \times 10^{-4}\, t$.

NaCl. In this case also n is independent of the concentration between 1/200 N and 1/3 N; its value is $n_t = 0{\cdot}622 - 7{\cdot}4 \times 10^{-4}\, t$.

KCl. Between 1/100 N and 1/5 N, n is independent of the concentration. At 11°, $n = 0{\cdot}503$; at 76°, $n = 0{\cdot}513$.

H_2SO_4. In a solution containing 0·24 per cent. of H_2SO_4 the values of n at different temperatures are given by the expression

$$n_t = 0{\cdot}160 + 15 \times 10^{-4}\, t.$$

Determinations are also made with solutions of the chlorides of lithium, ammonium, rubidium, cæsium, thallium, calcium, barium, cadmium; silver acetate and nitrate, copper sulphate and chloride, the chlorides of strontium, magnesium, manganese, and cobalt; sodium bromide, potassium iodide, nitric acid, sodium nitrate, thallium sulphate, magnesium sulphate, sodium carbonate, potassium carbonate; sodium, ammonium and calcium hydroxides, potassium permanganate, and oxalic and succinc acids, for the results of which the paper must be consulted, as also for a few experiments with concentrated solutions. T. E.

733. *Electrolytic Conduction under Pressure.* **A. Bogojawlensky** and **G. Tammann.** (Zeitschr. Phys. Chem. 27. pp. 457–473, 1898.)—The authors investigate the influence of pressure upon the conductivity of polyvalent ions, and also the manner in which that influence is affected by concentration, change of volume, and degree of dissociation. The conductivity λ of a solution is proportional to the number of ions in unit of volume, and inversely proportional to the ionic friction. By raising the external pressure p (1) the volume v of the solution is diminished, and hence the concentration is increased; (2) the viscosity, and consequently also the ionic friction, is increased; (3) the degree of ionisation α of the solute is changed; (4) the degree of ionisation α^1 of the solvent is also changed, according to the equation

$$\frac{1}{\lambda}\frac{\Delta\lambda}{\Delta p} = \frac{1}{v}\frac{\Delta v}{\Delta p} + \frac{1}{\eta}\frac{\Delta\eta}{\Delta p} + \frac{1}{\alpha}\frac{\Delta\alpha}{\Delta p} + \frac{\lambda}{\lambda^1}\frac{1}{\alpha^1}\frac{\Delta\alpha^1}{\Delta p}$$

where λ^1 is the conductivity of the solvent. The author proceeds to discuss the separate terms of this equation, and compares their experimental values with the formulæ given by various authors. As regards solutions containing more than monovalent ions he finds that dissociation does not equally affect the several hydrogen atoms in the molecule. It is always one particular hydrogen atom which is separated out first as an ion, and such ions probably often exceed the next set of hydrogen atoms more than a hundred times in number. As regards the manner in which the influence of pressure depends upon the degree of ionisation, Planck's formula

$$\frac{d \log k}{ap} = -\frac{\Delta v}{1{,}000\ \mathrm{RT}}$$

is practically verified.

The experiments were made with a special bulb cell enclosed in a cast-iron pressure cylinder capable of withstanding 500 atmospheres. Among the bodies experimented upon were water, HCl, NaCl, acetic, chloracetic, and phosphoric acids, ammonia, sodium phosphate and tartrate, and citric acid. E. E. F.

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734. *Drop Electrodes.* **G. Meyer.** (Wied. Annalen, 67. 2. pp. 433–438, 1899.)—Experiments with a fine jet of mercury or amalgam made to fall through various salt solutions lead to the following views: If the metal possesses the property of condensing the salt on its surface, the concentration of the solution in the neighbourhood of the jet is diminished. The condensed salt collects over the metal surface upon which the jet impinges and there the concentration is increased, but no metal goes into solution. If, however, the metal of the jet does not condense

the salt, some of the metal itself is dissolved. This explains all Palmaer's observations, which need therefore not be taken as confirming Nernst's theory of drop electrodes. E. E. F.

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735. *Electrolytic Formation of Alums.* **J. L. Howe** and **E. A. O'Neal.** (Chem. News, 78. pp. 236–237, 1898.)—A number of alums containing iron, cobalt, and chromium were prepared by electrolysis of solutions of metallic sulphates, strongly acidified with sulphuric acid. The anode consisted of a platinum dish resting on a coil of copper wire, whilst the kathode was a coil of heavy platinum wire dipping into a porous cell; the current usually employed was that yielded by four Bunsen cells. The iron-rubidium, iron-cæsium, cobalt-rubidium, and cobalt-cæsium alums, which have not previously been described, were obtained in the pure state and analysed. No alums of manganese or ruthenium could be obtained by the above method. N. L.

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736. *Efficiency of Electrolytic Processes.* **R. Moritz.** (Ind. Électrochim. 2. pp. 49–51, 1898.)—A short exposition of the theory of electrolytic dissociation. Secondary reactions are explained with regard to the electrolysis of NaCl. The liberated Na yields with water NaOH and H_2. The former is electrolytically dissociated into $\overset{+}{\mathrm{Na}}$ and $\overset{-}{\mathrm{OH}}$; the OH goes to the anode, where it is discharged, and combines with the chlorine to ClOH, which is again an electrolyte with the ions $\overline{\mathrm{ClO}}$ and $\overset{+}{\mathrm{H}}$. The ClO is liberated as Cl_2+O_2. The energy relations are not discussed. H. B.

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737. *Diaphragms for the Electrolysis of the Alkali Metal Chlorides.* **H. Becker.** (Ind. Électrochim. 2. pp. 41–42, 1898.)—A continuation of an earlier article (see 1898, Abstract No. 1079.) The patents of Hoefner, the An. Salines domaniales de l'Est, Beim, Marx, Stoerner, Comboul, Greenwood, and of Bamberg are briefly described. Mica, lime, magnesia, various liquids, and mechanical devices are recommended in these patents as materials for diaphragms. The article does not admit of a useful abstract. J. B. C. K.

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738. *Becker's Method of Copper Deposition.* **E. Ronco.** (Ind. Électrochim. 2. pp. 92–93, 1898.) After describing the defects of the methods of Cowper-Coles and of others, the author

gives details of the improved method of Becker. Copper is used as kathode material. This is prepared for use by depositing a coat of silver upon both faces, and by burnishing this deposit, first in the usual manner, and finally with dry precipitated sulphur, until a brilliant golden tint has been produced. This silver-coated kathode is then fixed in a frame of some insulating material, and is again hung for a short time in the silver depositing bath. It is then momentarily dipped in water containing 1 gramme nitric acid per litre, and without washing is transferred to an electrolytic bath containing copper sulphate as the electrolyte. By observing the usual precautions for the deposition of dense and adherent copper, a sheet is obtained which is covered on the one side with an adhesive coating of silver of splendid brilliancy, capable of any use to which rolled copper may be put. The cost of production is stated to be 3f. per kilo, while the selling value is from 8f. to 12f.

In a future article the author promises details of some of the articles made from this silver plate. J. B. C. K.

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739. *Sugar Refining by Electrolysis and Ozone.* **F. Peters.** (Zeitschr. Elektrochem. 5. pp. 265–269, 1898.)—Hagen, Depeissis, and Fahrig have proposed the use of ozone for sugar refining, while Schollmeyer and Dammeyer were the first to experiment with electrolytic methods for attaining the same end.

The author has investigated the results obtained when using first, ozone alone, secondly, electrolysis alone, and finally when using these two purifying agencies in combination. A Siemens ozoniser was used to produce the ozone for these trials.

An optical method was used for comparing the sugar juices after treatment. It was found that electrolysis and ozone in combination were more effective than either agency alone.

A useful tabular summary of the results is given; but the investigation did not extend to the question of comparative costs.

J. B. C. K.

GENERAL ELECTRICAL ENGINEERING.

740. *O'Keenan's "Endoxyque" Battery.* (Ind. Élect. 7. pp. 430–433, 1898.)—This cell consists of a zinc positive and a lead-lead sulphate negative in a solution of zinc sulphate. The special feature of the combination is the negative element, which is substantially the same as a fully discharged negative electrode of a lead accumulator.

A plate of electrolytically reduced spongy lead is exposed to the air till thoroughly oxidised and then immersed in dilute sulphuric acid to sulphate it. After rinsing in water to remove excess of acid it is ready for use.

During the working of the cell the lead sulphate is reduced to spongy metal, and it is regenerated by again putting through the above cycle of operations. The E.M.F. of the combination is about ·5 volt. Details are given of the mounting and arrangement of the plates and figures as to outputs and cost of working.

E. J. W.

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741. *Electrical Stage-appliances at Drury Lane Theatre.* (Electrician, 42. pp. 325–326, 1898.)—In this installation, which was designed by Mr. Edwin O. Sachs, the stage is divided into six large sections, each 40′×8′, of which two are raised and lowered in guides through 19′, by electric power. These sections or lifts comprise two steel-arched lattice girders braced together, 5′ 6″ apart, weighing 4¾ tons, and with the joists and flooring, between 6 and 6½ tons, of which 4 to 4½ tons are counterbalanced. Each lift is operated by a 7½ H.P. four-pole, enclosed, shunt-wound motor running at 520 rev. per min., connected through worm-gearing (104 : 1) to a shaft carrying two winding drums making 5 rev. per min. Steel wire ropes pass from these drums over guide-pulleys to the four corners of the lift, the speed of lifting being 16′ per min. A crab is combined with the drum shaft, so that it can be easily thrown into gear in the event of failure of the current, &c. The work was carried out by the Thames Ironworks Co.

C. K. F.

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742. *Improved Prony Brake.* **A. Wetler.** (Elektrotechn. Ztschr. 19. p. 658, 1898; also Écl. Électr. 17. pp. 290–292, 1898.) In this brake the action of a weight on an arm attached to the friction-blocks is assisted by a special form of spring balance, which is connected to a second arm also attached to the friction-blocks. By measuring the angle through which the arms are turned from a given position (*e.g.*, both arms horizontal), the torque for any given angle can be calculated from a formula, or,

by constructing curves, the torque can be obtained directly. Drawings and a diagram of the apparatus are given in the original paper. C. K. F.

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743. *Le Roy's Electric Heating Apparatus.* **J. Reyval.** (Écl. Électr. 17. pp. 154–159, 1898; 14. p. 317; Mém. de la Soc. des Ing. civils de France, Feb., 1898, pp. 236–237.)—The essential part of these heaters consists of a rod of agglomerated silicon, as pure as possible; the two ends of the rod are coated with metal and clamped in copper sheaths; the rod is enclosed in an exhausted glass tube having metal caps at its ends, adapted to fit into spring clips, forming the terminals, whereby current is supplied to the heater. The heater reaches a temperature of 700° to 800° C. in two to three minutes. The resistivity of silicon is very high (see 1898, Abstract No. 408), thus making it a very advantageous material for this purpose. Each tube will last from 800 to 1,500 hours and costs 5f. In a linen stove having four of the heaters above described, and supplied with an alternating current at 110 volts, the temperature was raised from 25° to 70° C. in a quarter of an hour, using 137 watt-hours, each tube requiring 135 to 150 watts to maintain it at its normal temperature. C. K. F.

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744. *Mechanical Application of Electricity.* **G. Richard.** (Écl. Électr. 17. pp. 261–271, 1898.)—This is a description of some controllers and transmitters. W. G. R.

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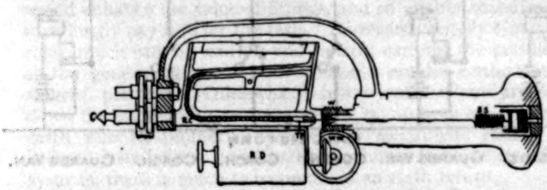
745. *New Apparatus for Measuring Torque.* **Boucherot.** (Soc. Int. Elect. Bull. 15 pp. 474–481, 1898.)—The apparatus described is extremely convenient for determining the relation between the speed and torque of a motor. The essential parts are shown in the accompanying sketch. A roller chain RC is fixed at one end to a tracing-point TP, which presses against the recording drum RD, and to a spiral spring SS. The far end of the chain is free. This chain is capable of sliding in a U-shaped groove or channel. When the centre C of the instrument is applied to the shaft of a motor, the frame containing the chain is set in rotation, and the centrifugal stress due to the radial portion of the chain causes an extension of the spring and a consequent displacement of the tracing-point. This displacement is proportional to the square of the angular velocity, since the mass of the radial portion of the chain remains constant. In order to counteract the friction due to the pressure of the chain against the outer wall of the upper part of the groove, this part is made slightly sloping. A reduction of the speed is obtained by means of the gearing shown at the left-hand side of the sketch. While

the frame carrying the chain and the recording drum is rotating, the drum itself is receiving a slow motion of rotation round its own axis by means of bevel-wheels and a worm-wheel WW, which gears into a worm W fixed to the handle of the instrument. The curve traced out by TP on the paper coiled round the drum is therefore one whose abscissæ are proportional to total angular distance θ swept out by the rotor of the motor, and whose ordinates are proportional to ω^2, where ω is angular velocity. Let now I stand for moment of inertia of rotor, and T for the torque exerted by it. Then—assuming no load on the motor, and neglecting frictional resistances—



$$T = I\frac{d\omega}{dt} \text{ so that } T\omega dt = I\omega d\omega, \text{ or } T = \tfrac{1}{2}I\frac{d(\omega^2)}{d\theta}.$$

Since $d(\omega^2)/d\theta$ may be obtained from the curve, we have at once a method of studying the variation of T with ω. The instrument is particularly valuable in testing induction motors: it may also be used in Routin's method of testing dynamos. (See 1899 Abstract, No. 199.) In order to find I, we may either actually measure T for one particular speed, or, keeping T constant, attach to the rotor a body of known moment of inertia. The instrument measures 30 cms. in length, and is made by Breguet. A. H.

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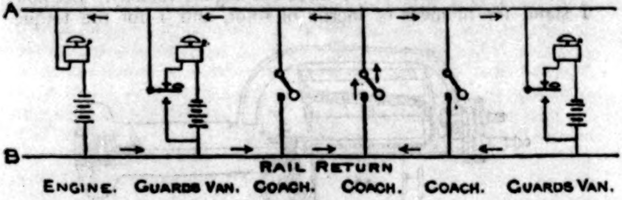
746. *Electric Intercommunication in Railway Trains.* **W. E. Langdon.** (Instit. Elect. Engin. Journ. 27. pp. 741–776, 1898. Discussion pp. 776–795, 1898.)—The author gives a historical summary of the subject, and describes the chief systems in use. Almost all are based on that devised by W. H. Preece, in which equal batteries are placed in the vans in series with bells, as shown in the annexed diagram, so that if any connection is made between the + and − conductors (A, B), all the bells are set ringing. Thus any passenger can call the attention of the guards, and the guards can signal to one another and to the driver. An insulated return is preferred to the use of the rails. Various methods of electrically coupling the coaches together are discussed; it is stated that the electrical and brake couplings should be entirely distinct. Interchangeability of the rolling stock of different railways is essential. The switches

and indicators used in the coaches are dealt with in detail. The paper concludes with extracts from the Report of the Committee appointed by the Board of Trade to investigate the subject.

The discussion dealt chiefly with details. **W. Leonard** stated that a separate indicator for each compartment was desirable, and that a combined electrical and brake coupling was to be preferred. **W. H. Winter** called attention to a system successfully applied on the Madras Railway, in which the side chains form the electrical connections. **F. Hollins** described the combination coupling in use on the Great Eastern Railway. A. H. A.



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747. *Wiring Rules.* **J. Pigg.** (Instit. Elect. Engin. Journ. 28. pp. 122–141, 1899. Discussion pp. 142–165, 1899.)—The discrepancies between the rules issued by the various Fire Offices Supply Companies and the I.E.E. are set forth in detail, and curves plotted showing the insulation resistance per lamp required under the various rules for different numbers of lamps fixed. The maximum discrepancy appears where 150 lamps are fixed, when the required figure for 110 volts varies from less than 7 megs. per lamp according to the Liverpool, London and Globe Office and the Board of Trade, to over 110 megs. per lamp according to the Westminster Electric Supply Company. In Appendix I. are given the rules of the various Fire Offices and Supply Companies, and in Appendix II. their insulation requirements. This paper was discussed with that given in the following abstract. E. H. C.-H.

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748. *Regulation of Wiring Rules.* **C. H. Wordingham.** (Instit. Elect. Engin. Journ. 21. pp. 166–173, 1899.)—Rules for securing efficient and safe wiring are essentially different from those securing satisfactory utilisation of the public supply. The standard set of the former should be of universal application, but the Supply Companies' regulations could at most be based on a model set. The Electric Lighting Acts do not give satisfactory powers for enforcing rules, and Glasgow, Manchester, &c. have obtained special Parliamentary powers for this purpose.

Fittings should be carefully supervised. At Manchester they now test and certify samples of fittings, thereby benefiting both consumer and manufacturer. The tests for a fuse are that when complete in position on the mains it shall break the current when it is short-circuited through a fuse-wire corresponding to its rated capacity. A switch has to break a current 50 per cent. above its rated capacity at 50 per cent. above its intended voltage. The author suggests the testing of fittings in a similar manner by some central authority, such as the I.E.E., whose certificates would enhance the value of fittings, and so enable manufacturers to willingly pay fees for the tests. As regards Supply Companies' rules, much can be said for and against earthing the middle wire at the generating station, but it should not be earthed at consumers' premises. Otherwise, if heavy local currents are flowing down the middle wire, currents will be set up from one consumer's earth wire to another's, with serious electrolytic results. For isolated installations, however, and for house-to-house transformer systems, there is much to recommend an earth return.

Discussion (pp. 175–191, 1899). **R. E. Crompton** advocated the adoption of the I.E.E. rules issued in July, 1897, as the standard to be prescribed by consumers, insurance companies and municipal authorities, and to be worked to by contractors. **B. Drake** attributed the comparative failure of the I.E.E. rules to the insurance inspectors wishing to have rules differing from those of other people. As an instance of disagreement, he quoted the regulations relating to fuses in ceiling roses; some rules require them, others forbid them. **F. Bathurst** criticised C. H. Wordingham's remarks on earthing, and questioned the occurrence of electrolytic troubles. If they did arise, the station engineer's duty would be to obviate them by developing his mains system, rather than to give up a cheap and reliable system which could compete with gas-piping in point of cost. **J. S. Raworth** objected to municipalities being given further dictatorial powers as to fittings. **C. Bright** pointed out that specific resistance *per se* is little indication of lasting good qualities in a dielectric: a prolonged insulation test by direct deflection is more valuable. **F. G. Baily** emphasised the unreliability of ordinary insulation tests of an installation. On a damp day in a new building, where porcelain has been extensively used it is difficult for the best work to give a satisfactory test. **M. O'Gorman** doubted if the I.E.E. rules would bear literal enforcement. Many recognised and admittedly safe systems would fail to comply with them. For wires, long immersion tests should be made; a good mechanical test with a low uniform and permanent electrical test is far superior to a poor mechanical result with high temporary megohms. He suggested alterations in detail to many of the I.E.E. rules. E. H. C.-H.

GENERATORS, MOTORS, AND TRANSFORMERS.

749. *Graphical Study of Shunt-wound Dynamo and Motor.* **Della Riccia.** (Bull. Ass. Ing. Él Liége, 9. pp. 413–463, 1898.)—The starting-point of the methods described in this paper is what the author terms the "principal" characteristic, *i.e.*, the curve connecting exciting current with E.M.F. on open circuit. When the machine is running loaded, the author regards its E.M.F. e as being made up of the sum of two terms; one e_f, which is due to the field-magnets, and which represents the E.M.F. on open circuit, corresponding to the exciting current actually traversing the field coils; and another, e_a, which is due to armature reaction; so that $e = e_f - e_a$. The term e_a increases with the load, and although not strictly proportional to the armature current, may be assumed to be so over the range of the principal characteristic used in practice. Hence, if v stand for the potential difference between the terminals, $v = e_f - (r_a + \rho)i_a$, where r_a and i_a stand for armature resistance and current respectively, and ρ is a constant (approximately) which represents the demagnetising effect due to the armature current. Assuming that the principal characteristic is given, and that the values of r_a, ρ and the shunt resistance and turns are known, the author shows how the ordinary characteristics may be deduced by a graphical construction from the principal one, and how the same graphical method may be applied to the solution of a large number of problems in connection with the shunt-wound dynamo and motor. A. H.

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750. *Armature Design.* **G. Grassi.** (Atti Della Assoc. Elettrotechnica Italiana, vol. i. p. 41; also Écl. Électr. 17. pp. 295–296, 1898.)—This article shows how to calculate the proper dimension of any new type of armature where it is impossible to refer to past experience.

If l is the length, d the diameter of the armature B the induction in the armature, and ϕ the total flux, then—

$$\phi = \beta\, l\, d\, \mathrm{B}$$

where β is a coefficient less than unity.

Also the volts generated are given by—

$$e = \frac{\mathrm{N}\, n\, \phi}{30}\, 10^{-8}$$

where N is the number of convolutions of wire on a two-pole drum wound armature, and n the number of revolutions per minute. If ν is the linear velocity of the circumference, then—

$$\nu = \frac{\pi\, d\, n}{60}$$

whence—

$$e = \frac{2}{\pi}\beta\, l\, \mathrm{N}\, \mathrm{B}\, \nu\, 10^{-8}$$

The ratio of the power lost in the armature to the total power generated is given by—

$$\gamma=\frac{r\,i}{e},$$

where i is the total current and r is the armature resistance; γ should not exceed 0·02.

Also—

$$r=\frac{1}{4}\rho\frac{2\,(l+d)\alpha}{s}\mathrm{N},$$

where s is the sectional area of the wire, ρ its specific resistance, and α a coefficient greater than unity. If q is the current density in the wire then—

$$i=2sq,$$

whence—

$$\gamma=\frac{\pi}{2}\;\frac{\rho\,\alpha\,q}{\beta\,\mathrm{B}\,\nu}\left(1+\frac{d}{l}\right)10^{8},$$

or—

$$\frac{d}{l}=\frac{2\beta\,\gamma\,\nu\,\mathrm{B}}{\pi\,\rho\,\alpha\,q}10^{-8}-1,$$

whence—

$$\gamma>\frac{\pi\,\rho\,\alpha\,q}{2\,\beta\,\nu\,\mathrm{B}}10^{8}.$$

Suppose that a cooling surface of m centimetres per watt is allowed, then—

$$\pi\,l\,d=m\,\gamma\,e\,i=m\,\gamma\,\mathrm{W}$$

W being the output of the dynamo.

We are then led to the relation—

$$d^{2}=\frac{m\,\gamma\,\mathrm{W}}{\pi}\left\{\frac{2\beta\,\gamma\,\nu\,\mathrm{B}}{\pi\,\rho\,\alpha\,q}10^{-8}-1\right\}$$

or—

$$d=\mathrm{A}\,\sqrt{\mathrm{W}}$$

Where A depends on the induction, the peripheral speed, the current density, and the coefficients α, β and m. Applying this result the author obtains, for—

$$\gamma=0{\cdot}01 \qquad \frac{d}{l}=0{\cdot}19$$

$$\gamma=0{\cdot}15 \qquad \frac{d}{l}=0{\cdot}785$$

$$\gamma=0{\cdot}02 \qquad \frac{d}{l}=0{\cdot}38$$

W. G. R.

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751. *Effect of Commutation on Field of Dynamo or Motor.* **W. H. Everett** and **A. H. Peake** (Electrician, 42. pp. 328–329, 1898).—(See Science Abstracts, vol. i. p. 362, No. 708, 1898.) The article gives the results of an investigation undertaken to determine in how far the changes of current taking place in the short-circuited coil of a dynamo or motor at the time of commutation affect the main field of the machine. The method adopted consists in using an exploring coil of fine wire wound on one of the armature coils, one end of this exploring coil being connected to a slip-ring, and the other to a revolving adjustable contact-maker. By this means the instantaneous E.M.F. (which is proportional to the field) corresponding to any portion of the coil could be determined. The field is found to be affected by the change of current in the coil under the brush, as is shown by the ripples in the curves obtained. A. H.

752. *Commutator Motors for Alternating Currents.* **G. Moulun.** (Écl. Électr. 17. pp. 465–473, 1898.) This is a lengthy mathematical discussion of the theory of the action of a four-pole series-wound motor when traversed by alternating currents. The field-magnets are well laminated, but otherwise the motor appears to be constructed as if for direct currents. Special attention is given to the action of the coils short-circuited by the brushes, and to the effect produced by altering their lead or lag. Formulæ are developed for the torque, output, efficiency, power factor, &c. of the motor; and these are worked out numerically from data taken from a 1 H.P. motor of the type referred to. The numbers so calculated agree very well with experimental results. The efficiencies given are fairly good for a 1 H.P. motor, but no data are given enabling one to compare the size and cost of this motor with those of a direct current motor of equal power. W. E. S.

753. *Görges Phenomenon and Tandem Coupling of Induction Motors.* **F. Eichberg.** (Zeitschr. Elektrotechn. Wien, 16. pp. 578–582 and 591–594, 1898.)—In 1896 Görges noticed certain peculiarities in the behaviour of a polyphase induction motor provided with a rotor having a single-phase or uni-axal winding, such as, *e.g.*, a single short-circuited turn of conductor round the rotor core. Such a motor, when working under maximum load, was found to run at a speed not much below *half* the speed of synchronism, and to give an efficiency of some 70 per cent. (instead of the 50 per cent. which an ordinary motor would give at that speed). When the rotor was driven at a somewhat higher speed than half that of synchronism, the machine acted as a generator; but when run up to a speed not far removed from that of synchronism, the rotor once more acquired a positive torque,

and could support a moderate load. At a later date the same effects were observed by Görges and others in the case of single-phase motors with a uni-axal rotor winding.

The author attempts an explanation of this puzzling phenomenon, and adopts the following method: Assuming, for the sake of simplicity, a two-pole rotating field, let the simple loop or coil which forms the rotor winding be replaced by two pairs of coils at right angles to each other, as shown in Fig. 1, and let the coils I, 1 each convey half the ampere-turns corresponding to the original loop, and co-phasal with them, while the coils II, 2 convey the same ampere-turns as I, 1, but in quadrature with them and in opposition of phase to each other. The magnetic effect is obviously the same as that actually due to the single loop. Let n = frequency of supply, m = speed of rotor, in revs. per sec. If the coils I, II, and 1, 2 be supposed placed on independent cores, the arrangement is equivalent to two ordinary polyphase motors, A and B, mechanically coupled, and electrically coupled, thus: The inducing winding of motor A is the field-winding of the actual motor, the frequency being n; the currents in the induced winding of A (coils I, II in Fig. 1) are of frequency $n-m$, and are the same as the currents in the inducing winding of B (1, 2 in Fig. 1), but with the connections interchanged, so that the field rotations are in opposite directions; the induced winding of B consists of the inducing or field winding of A, together with the whole of the supply network. The actual torque of the real motor is the algebraical sum of the torques of the imaginary motors. The torque-speed curves of these motors are shown (dotted and chain-dotted respectively) in Fig. 2, and from them is obtained the

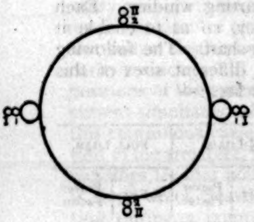


FIG. 1.

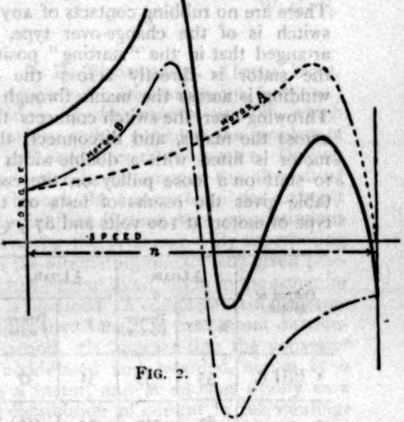


FIG. 2.

full-line curve, which gives the actual torque of the motor. The shape of this curve at once explains the apparent anomalies in the behaviour of the motor. The same method is applied by the author to the case of a single-phase motor. The problem of two motors coupled tandem, which is suggested by the above considerations, is also discussed. A. H.

754. *Langdon-Davies Single-Phase Motor.* (Electrician, 42. pp. 187–189, 1898.)—This article contains an illustrated description of the motor. The rotating part consists of a laminated core with a number of short-circuited coils wound on it. The stator is provided with two windings, one of which is always in action, while the other is only used at the moment of starting. There are no rubbing contacts of any description. The starting-switch is of the change-over type, the connections being so arranged that in the "starting" position the starting winding of the stator is directly across the mains, while its running winding is across the mains through a non-inductive resistance. Throwing over the switch connects the running winding directly across the mains, and disconnects the starting winding. Each motor is fitted with a double-width pulley, so as to enable it to start on a loose pulley on the counter-shaft. The following table gives the results of tests on three different sizes of this type of motor, at 100 volts and 87 ∿ per sec. :—

Output of Motor.	¼ Load.		½ Load.		¾ Load.		Full Load.	
	% Effy.	Power Factor.	% Effy.	Power Factor.	% Effy.	Power Factor.	% Effy.	Power Factor.
1 B.H.P.	35	·35	51	·47	57	·58	59	·67
4 ,, ,,	62	·39	74	·59	76	·73	72	·79
20 ,, ,,	54	—	73	—	77½	—	78	—

A. H.

755. *Braking of Single-Phase Induction Motors.* **F. Eichberg.** (Zeitschr. Elektrotechn. Wien, 16. pp. 541–544, 1898.)—Given a single-phase induction motor running at its normal speed, what electrical methods are there for rapidly reducing it to rest? The question is at present of theoretical rather than practical interest, and the author offers the following two solutions: 1. Introducing resistance into the armature circuit; the most powerful braking action is obtained when the total resistance of the armature

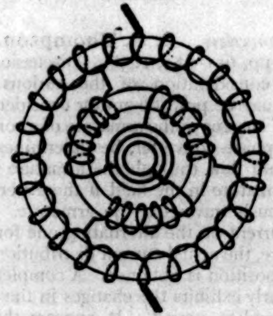
circuit equals double its reactance; 2. Suddenly increasing the number of field-poles, or connecting the motor to supply mains of lower frequency—either of which will render its speed greater than that of synchronism, and introduce a powerful retarding torque. The second method, however, can only be used down to a certain speed, for below this the torque of the motor again becomes positive. A sketch of the theory of the two methods, with graphical illustrations, and an account of some simple experiments on the first method are given in the paper.

A. H.

756. *Starting Devices for Motors.* **C. F. Guilbert.** (Écl. Électr. 17. pp. 301–310, 1898.)—This is a fully illustrated article on the various devices for the starting and regulation of direct current motors. W. G. R.

757. *Rotary Converters.* **S. P. Thompson.** (Instit. Elect. Engin. Journ. 27. pp. 651–689, 1898. Discussion, pp. 690–739.) —After a brief consideration of the various uses to which rotary converters may be put, the author considers the problem of the distribution of current in the armature of a converter. Dealing first with a single-phase converter, he determines the alternating current which would flow through the armature coil for different positions of the armature in the field if there were no continuous current simultaneously traversing the armature. By superposing this continuous current on the alternating one for any given position of the armature, the actual current distribution in the armature windings for that position is obtained. A complete set of diagrams is given which clearly exhibits the changes in the current distribution during a complete period. It appears that the converter armature is periodically accelerated and retarded, acting at a certain instant wholly as a motor, and at another wholly as a generator. The peculiar distribution of current in the windings produces unequal heating, the coils which are close to the slip-ring connectors being much more heated than those which lie midway along the periphery between the connectors. The total heating effect is somewhat greater than would occur in the armature if used as a continuous-current machine, but less than that corresponding to its use as an alternator; the ratios of the heating being as 1 : 1·366 : 2 in the three cases (for equal power). The single-phase converter is a much less satisfactory appliance than a polyphase one: it has considerable variations of armature reaction, a greater and less uniformly distributed heating, and requires more accurate setting of the brushes than polyphase converters; it is, further, not self-starting from the alternate-current side. The principle of superposition of instantaneous currents is next applied to determine the current distribution in two-phase and three-phase converters. The unequal distribution of heat is less in a three-

phase converter than in a single-phase, but is greater than in a two-phase converter; the coils subject to the greatest heating being in each case those in the immediate neighbourhood of the points of connection to the slip-rings. In the application of converters to charge accumulators from alternate current mains, some method is necessary of changing the voltage as between charge and discharge. The arrangement adopted by Ritter consists in using a small continuous-current dynamo which is connected in series with the continuous-current side of the converter, and which is either mounted on the same shaft or driven by a pulley from it. The P.D. is adjusted by varying the excitation of the auxiliary machine. The ratio of the E.M.F.s on the two sides of a converter is generally an awkward one in machines of ordinary construction. Two methods have been described for reducing this ratio to a more convenient number. One consists in altering the distribution of the magnetic flux by changing the width of the pole-pieces; the other, due to Neldt, and illustrated in the accompanying diagram, is to include on the alternating-current side additional windings (mounted on the same core) between the slip-rings and the armature winding proper. The paper concludes with a description, accompanied by drawings to scale, of some recent types of converter.



In the discussion, the effect of an accidental short-circuit of some 15 seconds' duration on a large converter is described. The converter was driven from the two-phase side and was fairly heavily loaded; it was running in parallel with a turbine-driven exciter of but $\frac{1}{7}$th the capacity. The alternating E.M.F. sank to zero, and when the short-circuit was burnt out the E.M.F. rose slowly and reached its normal value, the converter being still in step, and delivering its proper share of exciting current. It is pointed out that two converters working in parallel on the three-phase side cannot be joined up to give a three-wire system on the continuous-current side. The "hunting" of converters is alluded to by almost every speaker. This action may in some cases become very troublesome. The remedy is to be found in embedding heavy conductors in the laminated pole-pieces, the currents induced in these conductors tending to keep the armature rigidly in synchronism; and in using engines with a very uniform angular velocity for driving the generating plant. Triple concentric cables have been found to introduce troublesome unbalancing of the voltage, and should preferably not be employed where rotary converters are to be used. A. H.

758. *Rotary Converters.* **C. P. Steinmetz.** (Elect. World, 32. pp. 650–652, 1898.)—This is the first of a series of articles. The author calculates the following table on the assumption of a perfectly efficient machine:—

	Continuous Current.	Single Phase.	Three Phase.	Four Phase.	Six Phase.	Twelve Phase.	*n* Phase.
Volts between collector ring and neutral point.		$\frac{1}{2\sqrt{2}}$	$\frac{1}{2\sqrt{2}}$	$\frac{1}{2\sqrt{2}}$	$\frac{1}{2\sqrt{2}}$	$\frac{1}{2\sqrt{2}}$	$\frac{1}{2\sqrt{2}}$
Volts between adjacent collector rings.	1	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{2}}{2\sqrt{2}}$	$\frac{1}{2}$	$\frac{1}{2\sqrt{2}}$	0·183	$\frac{1}{\sqrt{2}\sin\frac{\pi}{n}}$
Amperes per line.	1	$\sqrt{2}$	$\frac{2\sqrt{2}}{3}$	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{2}}{3}$	0·236	$\frac{2\sqrt{2}}{n}$
Amperes between adjacent lines.	1	$\sqrt{2}$	$\frac{2\sqrt{2}}{3\sqrt{3}}$	$\frac{1}{2}$	$\frac{\sqrt{2}}{3}$	0·455	$\frac{\sqrt{2}}{n\sin\frac{\pi}{n}}$
Rating by mean armature heating.	1	0.85	1·34	1·64	1·96	2·24	

W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

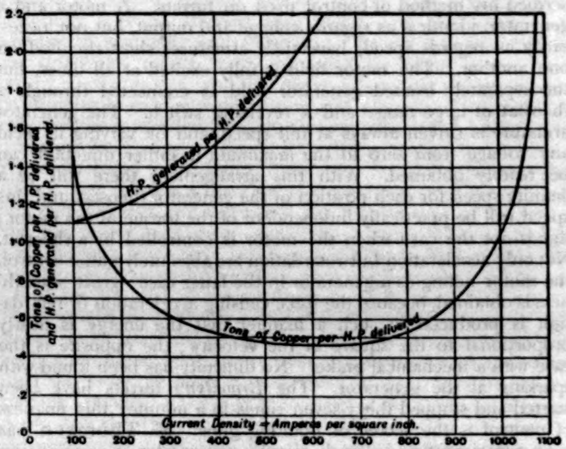
759. *Electricity on Board Ship.* **S. D. Greene.** (Amer. Instit. Elect. Engin. 16. pp. 21–35, 1899.)—The modern first-class battleship may require 1,000 I.H.P. for driving its auxiliaries at any one time, and the first-class cruiser 600 I.H.P. Power for these must be generated at a central point, and there can be used steam, hydraulics, compressed air, or electricity. Hydraulics and compressed air have a low efficiency of conversion (from steam) and it is difficult to prevent leaks, freezing, bursting, &c. With steam, the danger to life is considerable in action: men will face shot but not steam or hot water. Injurious heating of living quarters is almost inevitable with steam and exhaust-pipes. Electricity is more efficient than steam, and the motors are superior in simplicity and reliability. In the late war, two of the *Brooklyn's* turrets were controlled by steam motors and two by electric motors, and the officers report that the latter were far superior in ease of manipulation and fineness of control. A valuable paper, entitled "Steam Consumption of the Main and Auxiliary Machinery of the U.S.S. *Minneapolis*," by Engineer White, appeared in the Journ. Amer. Soc. Naval Engineers, Feb., 1898. This vessel is a first-class protected cruiser of about 7,500 tons displacement, and represents the highest type of her class. She has nearly forty steam auxiliaries. From White's observations during a seven days' run from Gibraltar to Philadelphia, the average steam-consumption of the main engines was 20·8 lb. per I.H.P. per hr., and of the auxiliaries, 119 lb. per I.H.P. per hr. These results are probably better than the average on most war-ships; under the most favourable conditions the auxiliaries probably consume at least 20 per cent. of the total coal and water used (or twice as large a proportion as in a modern central station). Assume 1,000 I.H.P. required at the motors in a vessel. A 250 volt or a three-wire system should be used in preference to the usual naval standard of 80 volts, which was fixed with a view to searchlights only. Assuming 82 per cent. efficiency for engine and generator, and 80 per cent. for line and motor, the overall efficiency between I.H.P. and B.H.P. at motors is 65·6 per cent. Thus 6–150 kw. sets, with one in reserve, would do, and the sets at work could be kept at full load, so that their steam consumption would be about 20 lb. per I.H.P. per hour, or about 30 lb. per B.H.P. hr. at motors. Allowing 25 per cent. margin for steam leakage, friction of gears, &c., we still have only 37·5 lb. per H.P. per hour as against the 119 lb. required in the *Minneapolis* tests, showing a saving of 70 per cent. With better compound engines, the average steam consumption on auxiliaries might be reduced to 75 lb. per H.P. per hour; but taking this figure, electric driving will show a saving of 10 to 20 per cent. in coal, corresponding to a proportionately greater steaming radius.

For a total maximum capacity of 2,000 H.P., the present weight of steam auxiliaries is about 100 tons. If electric drive is used, we must add 175 tons for the 7–150 kw. units, the weight of which is at present limited by the navy specifications to one-third of a pound per watt of rated capacity. Electric wiring will be lighter than steam piping, so that we may conclude that the electric plant will weigh from 2½ to 3 times the steam plant, but will save 10 to 20 per cent. in coal. In an Appendix an article is quoted from Cassier's Magazine, March, 1899, by G. W. Melville, confirming the large steam consumption in auxiliary machinery aboard warships, but pointing out that the extra weight and cost of electric motors prevent their use for forced-draught blowers and other little-used plant.

Discussion (pp. 36–56, 1899.). **H. Ward Leonard** described his method of control used on turrets. A motor and a generator, identical as regards voltage and output, but not necessarily as regards speed, have their armatures short-circuited on one another. The motor field is fully excited at all times, but the separately excited generator field is connected through a rheostat of large range and a reversing switch. The generator armature is driven always at full speed, and by varying its field any voltage from zero to the maximum in either direction can be readily obtained. With this arrangement there will be a definite speed for each position of the generator rheostat, and this speed will be practically independent of the torque of the motor; this is not the case when the motor is controlled by a rheostat. Not only acceleration but retardation are absolutely under control, the motor acting as a generator in the latter case; great smoothness is obtained, because the force causing acceleration or retardation is produced in such a manner that the energy is nearly proportional to the square of the velocity; the opposite is the case with a mechanical brake. No difficulty has been found with sparking at the generator. The *Brooklyn's* turrets have been started and stopped thirty-seven times in a minute: this fineness of control is the secret of pointing guns. **E. Thomson** has been experimenting on small, simple, non-condensing engines, on the same lines as M. Serpollet, and in a 4 H.P. engine can get 1 B.H.P. for 20 lb. of water per hour by imitating the gas-engine cycle. Dry or superheated steam at 160 to 200 lb. pressure is admitted behind piston by a poppet valve and exhausts through holes uncovered by the piston at the end of its stroke. The steam sweeps out all water, and what is left is driven back on dry hot surfaces. The engine has been operated with all degrees of superheat. The cut-off can be varied: two-thirds gives continuous torque. **J. W. Lieb, Jr.**, has seen German expert tests of 50 H.P. engines with Schmidt system of superheating showing less than 10 lb. steam consumption. **J. Bijur** finds that a drop of 25 volts between generator and searchlight arc is necessary for steady working: if the drop is increased to 110 volts, the regulating effect is too great and "hunting" results. E. H. C.-H.

760. *Long-Distance Power Transmission.* **G. Forbes.** (Soc. Arts Journ. 47. pp. 25–37, 1898.)—The gold-mining industry is particularly favourable to long-distance transmission, as it requires a continuous day and night supply of power, and the miner will frequently pay £70 to £100 per annum for the horse-power. Power may be economically transmitted 500 miles to the Rhodesian mines from the Victoria Falls. In the Coolgardie goldfields £180 per H.P.-year is offered, and the author has shown that it would pay to transmit power from steam engines at the coast, where coal and water are cheap, to a distance of 300 miles. Broadly speaking, the power required for rock breakers, stamps, &c., is such that 1 H.P. mills 1 ton of ore per day in hard quartz, the value of the gold being £3 or more per ton. At the rate of 1 ton a day, £100 per H.P.-year is equivalent to only 5s. 5d. per ton of ore for milling expenses. Cairo could be more cheaply lighted by power generated at the First Cataract, 400 miles away, than by steam engines at Cairo. To minimise capital expense, the author proposes the division of capital account into two parts—ordinary speculative stock, and bonds on the copper, which he considers the soundest of investments. Four per cent. ought to cover the chances of a change in market value of the copper.

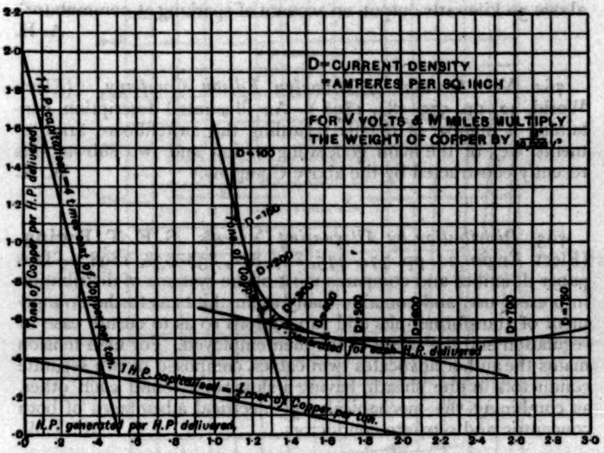
Fig. 1.



Rapid calculations for any special case of long-distance transmission may be made from curves or tables, based on current density, drop of volts and inefficiency (H.P. generated per H.P. delivered). If power cost nothing the cheapest arrangement would be an inefficiency of two (see Fig. 1). The curves and tables are drawn for 10,000 volts continuous current, and only require correction for temperature and sag. They are equally applicable to single or two-phase transmission at 10,000 effective volts or at 5,000 effective volts from any wire to the middle of the electric system or to three-phase transmission at 5,000 volts from any wire to the middle of the electric system; but with alternating current, corrections must be made for self-induction and capacity.

Fig. 2 gives the inefficiency at each current density and the tons of copper per H.P. delivered at 100 miles, with 10,000 volts continuous current, in terms of the inefficiency. For any other volts V, and distance M miles, the multiplier for current density is V/100M and the divisor for tons of copper per H.P. is $(V/100M)^2$. Divide the tons of copper per H.P. by 18 times the distance in miles and we get the sectional area in sq. ins. of the conductors (go and return) per H.P. Multiply this by the total H.P. to be delivered and we get the size of the conductors. Tables on which the curves are based follow. E. H. C.-H.

FIG. 2.



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761. *Polyphase Transmission of Power.* **F. Wallis.** (Electrician, 42. pp. 219–221, 1898.)—The author discusses the relative merits of the various systems. Thury advocates the use of continuous currents, and there are a number of power plants arranged on this plan. (See 1898, Abstract No. 874.) The continuous-current system is by far the most economical as regards copper in the line, the relative figures for continuous-current,

single-phase, two-phase (four-wire), and three-phase circuits being ·5 : 1 : 1 : ·75, assuming the same maximum P.D. in each case. The main disadvantages of the continuous-current system are the impossibility of using very large units (with the corresponding gain in efficiency and first cost) and the risk of accident to the attendants or machines. The single-phase alternating system is well adapted for long-distance transmission in cases where there is one receiving station with only one or two synchronous motors. Where a large number of smaller motors have to be supplied, a polyphase system is better, as it does away with the self-starting difficulty; further, it has the advantage of being peculiarly well adapted for use with rotary converters (with single-phase currents there is a difficulty in constructing rotary converters of much above 50 kilowatts output, on account of sparking at commutator).
A. H.

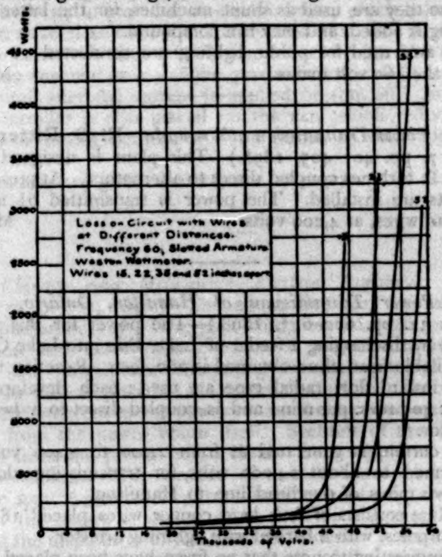
762. *New Stations of Brooklyn Edison Company.* (Elect. World, 32. pp. 579–584, 1898.)—An illustrated description, containing a number of details regarding the switchboard arrangements, &c., of the main generating station and two sub-stations recently constructed by the above Company. A. H.

763. *Distribution by Alternating Currents.* **S. E. T. Ewing.** (Elect. Engin. 22. pp. 774–775, 817–818, 837–838, 1898.)—This paper describes and compares most of the systems of distribution in present use, and contains many useful hints as to the arrangement of transformer-pits and sub-stations so as to ensure ease of regulation and the safety of the men employed. For high tension mains the author advocates twin cables, composed of two separate conductors in one sheath, having a slow twist round each other, as combining the mechanical and electrical advantages of both concentric and separate conductors. M. G. W.

764. *High-Voltage Power Transmission.* **F. Scott.** (Amer. Instit. Elect. Engin. 15. pp. 673–718, 1898.)—This paper contains the results of some valuable experiments in high tension transmission. Some of the experiments were made in laboratories, but the greater number are tests made under actual conditions of working on an overhead line 2½ miles long, at Telluride, Colorado, a continuous run of thirty-seven days at 50,000 volts being made to try the line. The voltage finally adopted for commercial transmission on this line was 40,000 volts.

The principal conclusions are as follows: The total loss is made up of loss over insulators and loss between wires, the former being comparatively negligible. The loss between wires depends on the diameter of the wires, the distance between them, and the wave form of the E.M.F., but the variations which may occur under favourable commercial conditions locate the point of increase of loss at about 50,000 to 60,000 volts. The loss between wires is not affected by any atmospheric conditions except precipitation; this statement must of course be taken as applying to a climate similar to that in which the measurements were made. The lines were seldom in fog, and when they were so, or when rain was falling, the moisture was pure, the line being distant from any large town.

For a given transmission there is a certain economical voltage, since increasing the voltage, while decreasing the loss in the wires, increases the loss between them. It is believed that the sine wave form is the best for this class of work.



Glass insulators have more points in their favour than porcelain. All breakdowns on poles occurred at cross-arms that had been strained and cracked by weather; the salts from the body and surface of the wood probably settle in these cracks, and the current follows the line of them.

The paper contains curves of all the results obtained, sketches of insulators, lightning arresters, &c., and a full description of all the apparatus used in the experiments.

One of the curves showing the loss between wires at different distances apart and with varying voltages is reproduced with this abstract. M. G. W.

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765. *Carlisle Electric Supply Station.* (Electrician, 42. pp. 294–298, 1898.)—The system adopted at Carlisle is the three-wire system, with an earthed middle wire, and 460 volts between the outers. Steam-driven balancing dynamos are used and a battery. The boosters are arranged so that they can be used in series with the cells, and add to the voltage of the dynamo during charge, and to the voltage of the cells during discharge.

An exceptional feature in the plant is the provision made for utilising the dynamos either for the 460 volts lighting network or the contemplated 500 volts tramway system; for the former purpose they are used as shunt machines, for the latter a series winding is added, and they run compound.

The arcs used for public lighting are connected 10 in series across the 460 volt mains. M. G. W.

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766. *Power Transmission at Granada.* **R. B. Ritter.** (Ind. Elect. 7. pp. 401–405, 1898.)—This plant is designed for ten 340 H.P. turbines coupled direct to alternators. At present only two sets are installed. The power is transmitted 6¼ miles on overhead wires, at 4,200 volts. M. G. W.

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767. *Power Transmission at Hamilton, Ontario.* (Elect. World, 32. pp. 620–623, 1898.)—The power for this plant is derived by discharging a feeder of Lake Erie into Lake Ontario; the available head thus obtained is 260 feet. Reaction turbines of the inward flow radial type are used; each develops 1,950 H.P. at 400 revs. per min., and is coupled direct to a two-phase alternator.

The current is generated at from 2,000 to 2,400 volts, and transformed to about 24,000 volts for transmission along the thirty-five miles of overhead line to Hamilton.

The line consists of four bare copper wires placed 18 inches apart on poles, with a barbed wire lightning arrester.

It is interesting to note that no fuses have been placed on the generator switchboards, a short circuit being considered less dangerous than a sudden throwing off of load with turbine gates full open.

The article contains particulars of many ingenious mechanical arrangements, and is fullly illustrated. M. G. W

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768. *McGurly High-Speed Mail System.* (Elect. Engin. N.Y. 26. p. 183, 1898.)—The system invented by McGurty is for the purpose of carrying mail, newspapers, and express matter at a high rate of speed, embodying devices to have the car stop at any desired station, and doing away with an attendant on the car.

The system involves the use of a new automatic controller and trolley, and also insulated sections and brake. The cars will be 30 feet in length, with a capacity of 40,000 lb., and will be designed to run at 120 miles per hour. The car is fitted with a new type of alternating current motor, one of which is mounted directly on the front, and one on the rear axle of the car. On board the car is an automatic rheostat for starting the car, there being no attendant. This rheostat embodies a mechanism by means of which the car can be started as slowly or rapidly as is desired, bringing it up to speed in one or two minutes, or even less. There is also provided an electric brake, which comes into operation as soon as the current is applied to it, and is released when the current is shut off. It can be so regulated by springs as to stop the car at a definite predetermined place, and any desired time after the current is applied or shut off. An automatic controller is also placed on the car, which reduces the speed when turning corners, or down grades, or when approaching stations.

Illustrations are given showing the arrangement of the track and car. L. J. S.

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769. *Chicago and Milwaukee Electric Railway*. (Elect. World, 32. p. 207, 1898.)—The above line may be called an inter-suburban railway. The plan which was adopted for power generation and distribution consists of a combination direct current and three-phase alternating current system, with a generating station placed at the centre of the line. The sections of the road adjacent to the power station are supplied with direct current from the power house itself. Sections of the line at a distance from the power house obtain their supply of current from sub-stations. The location of these sub-stations and their distance apart is governed by the conditions of traffic and somewhat by the nature of grades along the line. A map is given showing the disposition of the line and feeders. A novel feature is to be found in the electrical equipment of the power station. Two different types of generators are employed, one is an alternating three-phase generator, having a capacity of 250 kw. and working at 25 cycles per second. The current is generated at a potential of 5,500 volts, ready to be delivered directly to the transmission lines without the use of transformers. The second type of machine is a combination generator. It is also a 250 kw. machine, and can deliver its output either as a direct or as a three-phase current. The windings of the armature are connected on one side to a commutator and on the other side to collector rings. The potential of the direct current end is 600 volts, while the three-phase current is delivered at a pressure of 380. This machine can be used to supply current directly to the trolley passing in front of the power station, or can be used to operate

the motors in the sub-stations, or for both purposes, at the same time dividing the load in proportion to the demand.

When the three-phase current from this generator is transmitted to the sub-station the pressure is raised from 380 to 5,500 volts by means of transformers, which are cooled by a blast fan operated by a 1 H.P. induction motor. The sub-stations are arranged each to contain step-down transformers, a rotary converter, and a storage battery. The electrical equipment of the sub-stations is not in duplicate. This has been considered unnecessary, as it is intended to mount the machinery needed for a sub-station, viz., step-down transformers and one rotary converter, upon a truck fitted with motors. In case of breakdown at any sub-station, the battery can be relied on to supply current for several hours, during which time the portable reserve sub-station equipment can propel itself to the crippled station, and be connected ready to operate until the repairs have been made. L. J. S.

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770. *Bastille-Charenton Electric Tramway.* (Écl. Électr. 17. pp. 317–329, 1898.)—The greater part of this line is worked on the trolley system, but in some parts of the city the current is brought to the motors by an underground conduit. A point of novelty in connection with this line is the use of rails bonded by the Falk system, which is said to result in exceedingly smooth running. The cars employed are of a light construction, with a frequent service.

Apart from the ordinary generators at the power station, a battery of accumulators is employed, consisting of 250 cells with a capacity of 350 ampere hours. This battery is used not only for steadying the load of the generators, but also for supplying currents to the underground portion of the circuit, and for lighting purposes after the stopping of the traction service. The underground portion of the circuit consists of two insulated cables isolated from the remaining overhead portion of the circuit.

Details of the installation are given *in extenso.* L. J. S.